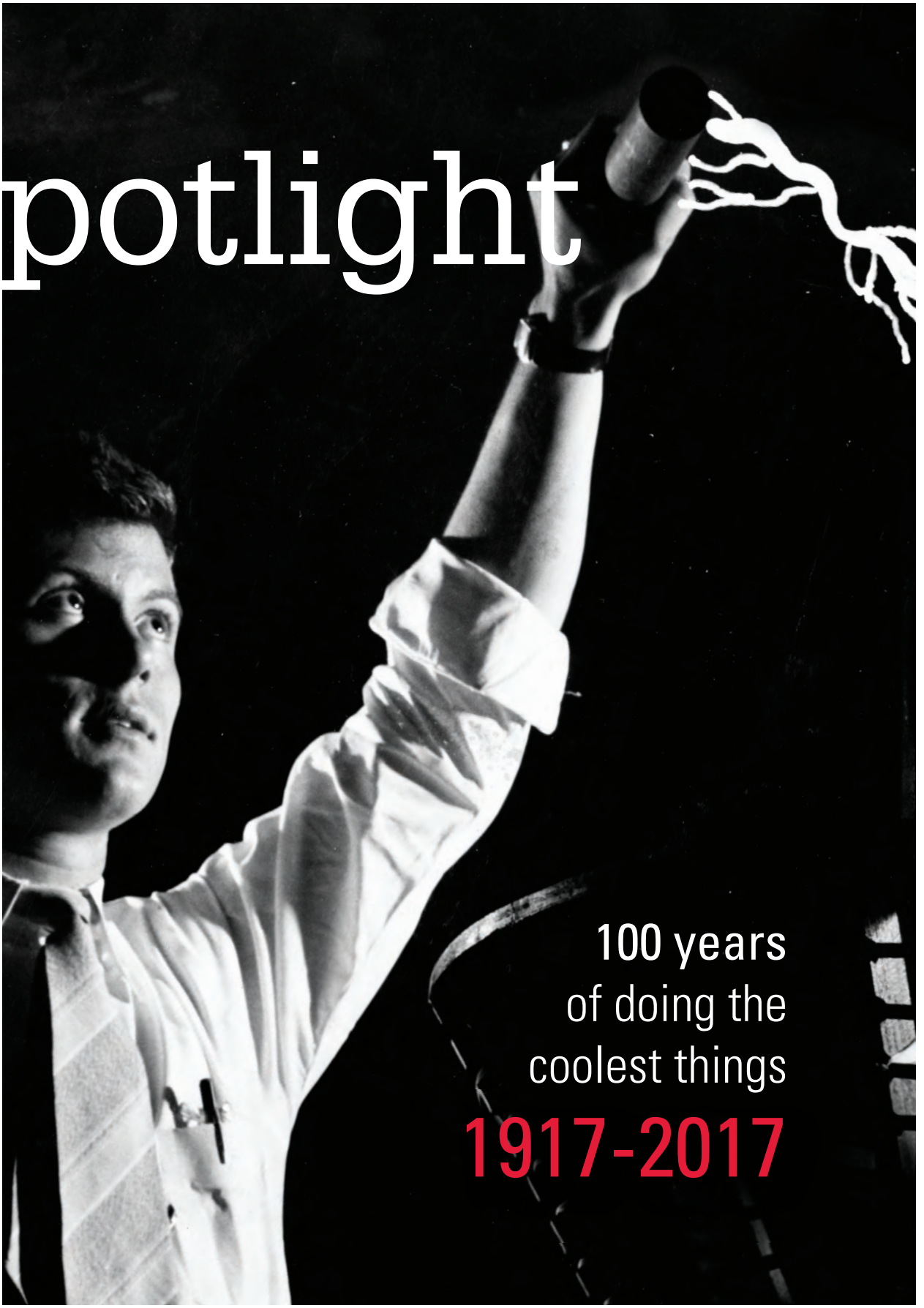
Electrical & Computer Engineering

Spotlight



100 years
of doing the
coolest things
1917-2017

NC STATE UNIVERSITY

In this Spotlight

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Department Head's Note

1917 was a very eventful year. Albert Einstein published his first paper applying the general theory of relativity to model the structure of the universe; the International Red Cross won the Nobel Peace Prize; Woodrow Wilson was inaugurated for his second term as U.S. President; the Seattle Metropolitans won the Stanley Cup; the Chicago White Sox won the World Series; the United States entered World War I; it was the year of the Russian Revolution; Ella Fitzgerald, Dizzy Gillespie, Arthur C. Clarke and John F. Kennedy were born; and the Department of Electrical Engineering at NC State was separated from Physics to become its own department. Since 2017 marks the 100th anniversary of our Department, in this issue of the Spotlight we are celebrating "100 years of doing the coolest things." In keeping with this theme, I would like to tell you about a few of the interesting things in the history of the ECE department.

The first course in Electrical Engineering was taught in the Physics department around 1893, or shortly thereafter. By the end of the 1890's, the department became known as the Department of Physics and Electrical Engineering.

Professor William Hand Browne, Jr., came as head of the Department of Physics and Electrical Engineering in 1908. He became the first head of the Electrical Engineering Department when it was separated from Physics in 1917, and remained until his retirement in 1944.

The 1917 budget for the School of Engineering listed only two members of the Electrical Engineering faculty: Professor Browne and Associate Professor Henry Knox McIntyre. Browne, in correspondence dated September 1920, listed problems of accommodating large classes: 35 juniors, 49 sophomores, and 70 freshmen!

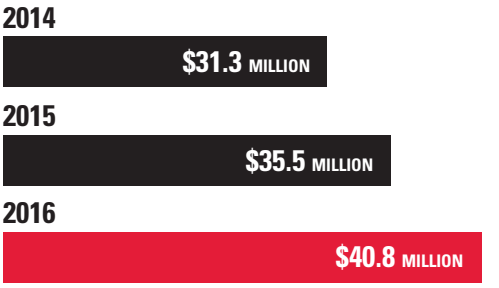
Things have changed a bit today! We now have 57 tenured or tenure-track faculty (and growing), about 1000 undergraduates, and about 850 graduate students. We are consistently among the top 10 U.S. Departments for the number of B.S. degrees granted in Electrical Engineering and Computer Engineering, and we are also in the top 10 in terms of research expenditures.

There are many things in our past to be proud of, but I would like to call your attention to several that speak to the values and culture of the Department. As highlighted elsewhere in this issue of Spotlight, the first female student in Engineering at NC State was Lucille Thomson who entered the Electrical Engineering program in 1921; the first African American graduate of the University was Robert L. Clemons who received a professional degree in Electrical Engineering in 1957; Irwin Holmes was the first African American to receive an undergraduate degree from NC State when he received a bachelor's degree in Electrical Engineering in 1960; and the first female Ph.D. faculty member in the College of Engineering was Sarah A. Rajala who joined the Electrical Engineering Department in 1979. In keeping with these historical values, today we are consciously trying to ensure that everyone is welcome in our Department, and that everyone's success is determined by what they can do rather than who they are or what they look like.

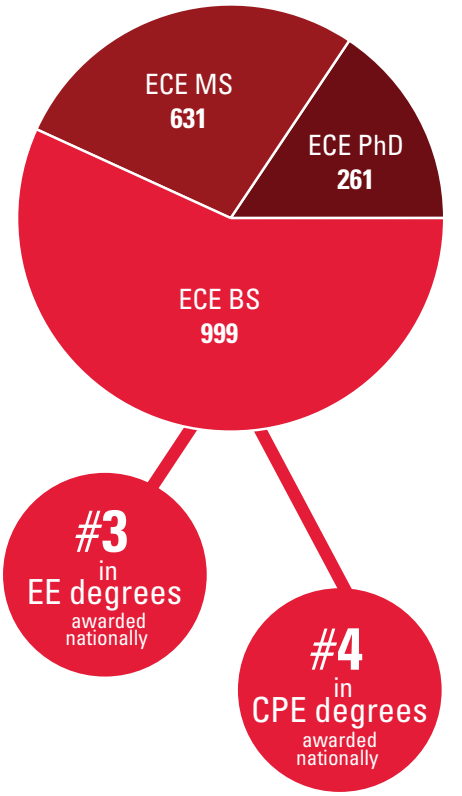
The first 100 years have certainly been impressive, but wait until you see what we do in the next 100 years!

Dr. Daniel D. Stancil
ECE Department Head

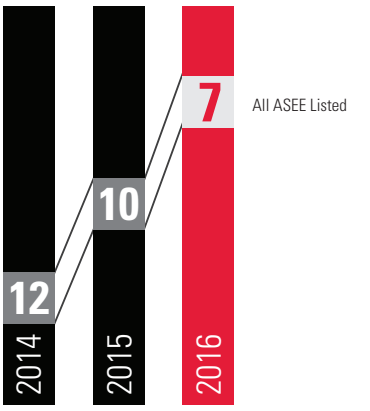
Total ECE Research Expenditures



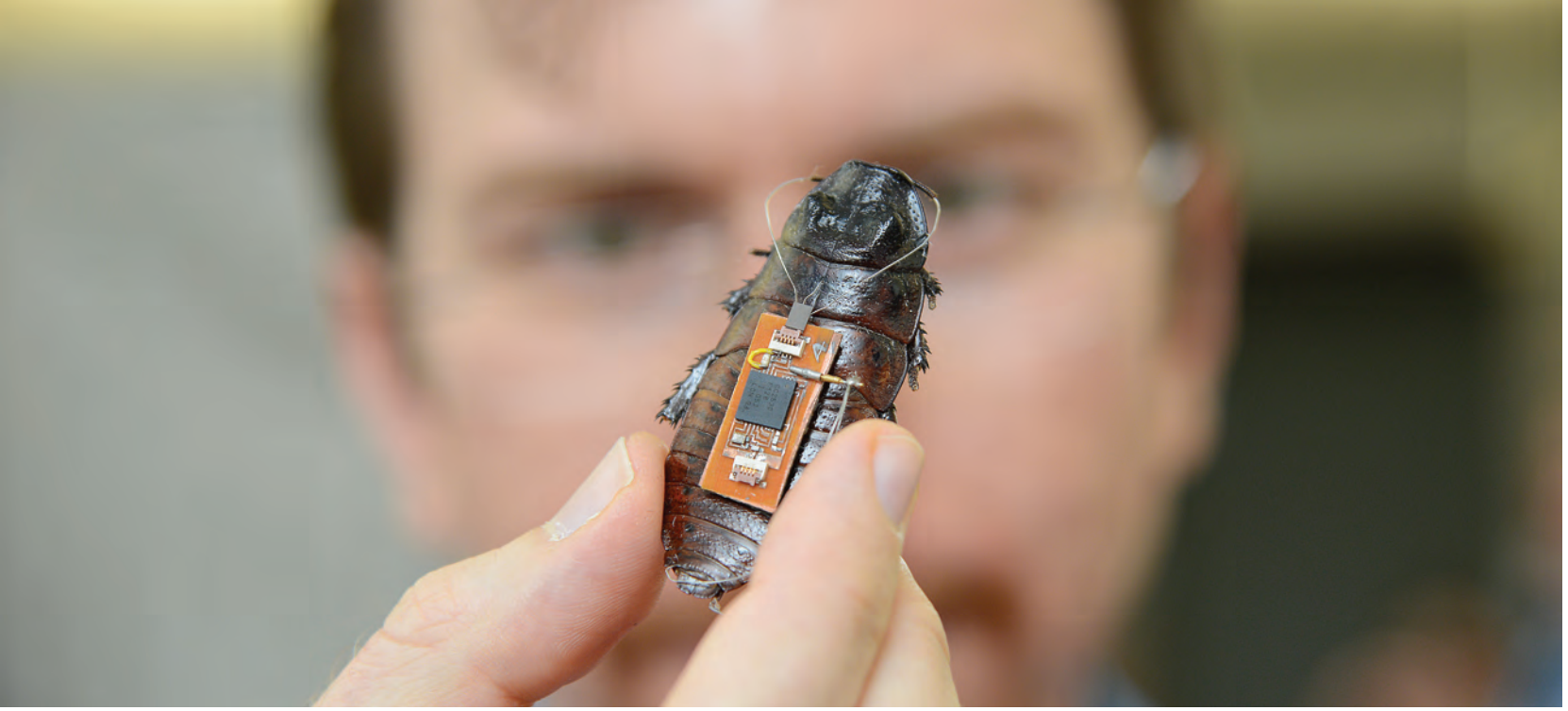
Total ECE Enrollment by Degree for 2016



Rank by Total Research Expenditures



Source: **American Society for Engineering Education**



Insect Biobots to the Rescue

Researchers at North Carolina State University's Department of Electrical and Computer Engineering have developed a combination of software and hardware that will allow them to use unmanned aerial vehicles (UAVs) and insect cyborgs, or biobots, to map large, unfamiliar areas - such as collapsed buildings after a disaster.

"The idea would be to release a swarm of sensor-equipped biobots - such as remotely controlled cockroaches - into a collapsed building or other dangerous, unmapped area," says **Dr. Edgar Lobaton**, an associate professor of electrical and computer engineering at NC State and co-author of two papers describing the work.

"Using remote-control technology, we would restrict the movement of the biobots to a defined area," Lobaton says. "That area would be defined by proximity to a beacon on a UAV. For example, the biobots may be prevented from going more than 20 meters from the UAV."

> The biobots would be allowed to move freely within a defined area and would signal researchers via radio waves whenever they got close to each other. Custom software would then use an algorithm to translate the biobot sensor data into a rough map of the unknown environment.

For this technology to become viable, the researchers needed to answer fundamental questions about how and where the biobots move in unfamiliar territory.

The researchers followed biobot movements visually and compared their actual motion to the motion being reported by the biobot's inertial measurement units. The study found that the biobot technology was a reliable indicator of how the biobots were moving.

Researchers then introduced biobots into a circular structure. Some biobots were allowed to move at will, while others were given random commands to move forward, left or right.

The researchers found that unguided biobots preferred to hug the wall of the circle. But by sending the biobots random commands, the biobots spent more time moving, moved more quickly and were at least five times more likely to move away from the wall and into open space.

"Our earlier studies had shown that we can use neural stimulation to control the direction of a roach," explained **Dr. Alper Bozkurt**, an associate professor of electrical and computer engineering and co-author of the two papers. "This study shows that by randomly stimulating the roaches we can benefit from their natural walking and instincts to search an unknown area. Their electronic backpacks can initiate these pulses without us seeing where the roaches are and let them autonomously scan a region."

"This has utility for areas - like collapsed buildings - where GPS can't be used," Lobaton says. "A strong radio signal from the UAV could penetrate to a certain extent into a collapsed building, keeping the biobot swarm contained. And as long as we can get a signal from any part of the swarm, we are able to retrieve data on what the rest of

the swarm is doing. Based on our experimental data, we know you're going to lose track of a few individuals, but that shouldn't prevent you from collecting enough data for mapping."

Once the program receives enough data to map the defined area, the UAV moves forward to hover over an adjacent, unexplored section. The biobots move with it, and the mapping process is repeated. The software program then stitches the new map to the previous one. This can be repeated until the entire region or structure has been mapped; that map could then be used by first responders or other authorities.

However, to test their new mapping technology, the research team relied on inch-and-a-half-long robots that simulate cockroach behavior.

In their experiment, researchers released these robots into a maze-like space, with the effect of the UAV beacon emulated using an overhead camera and a physical boundary attached to a moving cart. The cart was moved as the robots mapped the area.

"We had previously developed proof-of-concept software that allowed us to map small areas with biobots, but this work allows us to map much larger areas and to stitch those maps together into a comprehensive overview," Lobaton says.

> "It would be of much more practical use for helping to locate survivors after a disaster, finding a safe way to reach survivors, or for helping responders determine how structurally safe a building may be."

"The next step is to replicate these mapping experiments using biobots, which we're excited about."

From Transformers to Autonomous Systems

Dr. Edgar Lobaton, Associate Professor

Autonomous systems are becoming a reality in our everyday lives. A few examples that most of us have seen in the news include autonomous vehicles such as the Google Car, and autonomous stores such as Amazon Go. All of these systems require sophisticated sensing, machine learning and artificial intelligence in order to make them work, which fascinates me.

My passion for machine learning and autonomous systems started when I was a little kid.

I was in my first year as an elementary school student in Peru, waiting diligently every weekend in front of the TV in order to catch an episode of the Transformers animated series. Sitting on my parents' couch, hearing the classic tune describing the robots as "more than meets the eye," the same thought would keep going around and around in my head: "I've got to have one."

Growing up in a third-world country, my parents could not afford to buy Transformers toys for me. As a resourceful kid, I did the next best thing: I decided to build my own. With the limited resources I had, I started to build my own robots. At age five, I started by drawing my first Transformers on a piece of paper, cutting them out with my bright red training scissors, and then folding legs and arms in order to convert them into little squares. Not the most useful Transformers, but it was a first attempt.

A couple of years later, my dad taught me how to make cubes out of paper, so I ventured to build my first 3D Transformer. With a little ingenuity, and using some rubber bands and pins, I was able to make Transformers with movable joints. Not full transformation, but at least the arms and legs could bend.

By the time I was a high school student (still in Peru), I had already figured out how motors, gears, electromagnets and pulley systems worked, which allowed me to build some simple robots that could move around. However, this was still far from becoming a sentient, autonomous robotic system. What was missing was for the robots to understand their surroundings and be able to make decisions based on that information.

Read more about Dr. Lobaton's journey towards autonomous systems at **go.ncsu.edu/transformers**

Welcoming New Faculty

The NC State Department of Electrical and Computer Engineering is proud to announce the addition of four new assistant professors to our accomplished faculty. A variety of scholars from across the country will be joining the Wolfpack to lend their experience and expertise to our students and research.

Dr. Shih-Chun Lin – His research interests at Georgia Tech include wireless communication and networking, specifically wireless software-defined networking (SDN) and network function virtualization (NFV) solutions for 5G systems, cognitive cyber-physical systems (CPS), wireless communications in challenged environments (underground and underwater), Internet of Things (IoTs), ad-hoc and sensor networks.

Dr. Wenyuan Tang – Since completing his Ph.D. in Electrical Engineering from the University of Southern California in 2015 he has been a post-doc with a joint appointment between U.C. Berkeley and Stanford. His research interests include control and optimization of power systems, analysis and design of electricity markets, and data analytics for cyber-physical systems and social networks. He will be part of the new Sustainable Energy Interdisciplinary cluster.

Dr. Spyros Pavlidis – Since completing his Ph.D. in Electrical and Computer Engineering from Georgia Tech in 2016 he has been a post-doc in their School of Materials Science and Engineering. His research interests include high-frequency hybrid GaN/organic circuits and systems, GaN power electronics devices, and InGaZnO thin film transistors for wearable sensor applications. He will be working closely with the PowerAmerica Institute.

Dr. Chau-Wai Wong – He completed his Ph.D. in Electrical and Computer Engineering from the University of Maryland in 2017 under the supervision of Dr. Min Wu. His research interests are in the area of multimedia forensics, i.e., the extraction of "micro traces/signals" buried in physical, environmental, and physiological systems such as image, audio, and video systems. He will be part of the new Digital Forensics Interdisciplinary cluster.

Stancil Named President of ECEDHA

Dr. Daniel D. Stancil, Alcoa Distinguished Professor and Department Head of Electrical and Computer Engineering at North Carolina State University has been named president of the Electrical and Computer Engineering Department Heads Association (ECEDHA).

"ECEDHA is an outstanding organization that is helping to set the strategic agenda for Electrical and Computer Engineering as a discipline. It is an honor to be able to serve as president, and I am excited about this opportunity," said Stancil.

Stancil will serve as president for the 2017-18 year and leads a 15-person Board of Directors for the organization in its pursuit to advance the field of electrical and computer engineering, facilitate idea exchange and member interaction, and improve communication with the profession, industry, government and others.

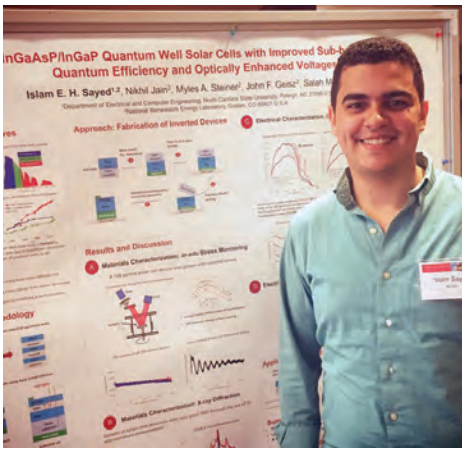
"Dr. Stancil's leadership comes at an important time for both ECEDHA and the ECE community as a whole. Through the efforts of its committees and working groups, ECEDHA has made great strides in addressing some of the most critical issues facing ECE today. We look forward to his guidance as we continue to impact the future of ECE," said John R. Janowiak, Executive Director, ECEDHA.

Dr. Stancil is not the first NC State Department Head to lead the organization. The Association of Electrical Engineering Department Heads (AEEDH) was first organized in 1963, and Dr. George Hoadley was its first Chair. Dr. Hoadley served as Head of the (then) Department of Electrical Engineering at NC State from 1954 to 1974.

VieMetrics Wins at LuLu eGames

VieMetrics, a team that has developed a low-cost, portable spirometer that can potentially predict asthma attacks, won the $10,000 first prize for new ventures at the 2017 Lulu eGames. The VieMetrics team includes Eric Beppler and Charles Hood from electrical and computer engineering. The team was advised by two professors from ECE - **Dr. John Muth** and **Dr. Alper Bozkurt**.

The company has developed a simple device to help those with breathing problems like asthma or COPD predict when they might have an attack. Vitaflow is the name of the spirometer - instrument for measuring breathing capacity - developed by VieMetrics. The team is also now turning its attention to new developments.



Best Poster at Energy Conference

Islam Sayed, a Ph.D. candidate electrical and computer engineering, advised by **Dr. Salah Bedair**, won the Exemplary Student Poster award at the 2017 State Energy Conference of North Carolina.

Sayed's poster, titled "InGaAsP/InGaP Quantum Well Solar Cells with Improved Sub-bandgap Quantum Efficiency and Optically Enhanced Voltages", was chosen from amongst other students' submissions from the University of North Carolina, Duke University, Appalachian State University, and East Carolina University.

Bedair's research group is primarily focused on high efficiency photovoltaic (PV) solar cells and investigating new materials and device structures for future PV concepts.

IEEE Control Systems Prize

Nan Xue, a student in **Dr. Aranya Chakrabortty's** research group is the receipient of the second place prize in a student video contest organized by the IEEE Control Systems Society. The award consists of a certificate and $500, which will be presented at the IEEE CCTA conference in Hawaii.

The video introduces a new design framework called control inversion for controlling large-dimensional network systems. By exploiting the clustering property of network systems, this design framework not only improves the tractability of the design, but also provides much simpler communication topology needed for control feedback.

SensUs in Netherlands

NC State ECE students participated in the SensUs Competition in September 6-8, 2017. SensUs is an international research competition in biosensors and conference held in Eindhoven, Netherlands.

The NC State team—SenseNC—was led by **Dr. Michael Daniele** and tasked to create a sensor to detect NT-proBNP, a biomarker for identifying heart failure. The SenseNC design operates using a compact disk-based sensor, which contained a multiplexed immunoassay. Small samples of human blood plasma containing NT-proBNP are loaded into chambers on the compact disk and centrifugal force is used to move the sample from chamber to chamber in a coordinated sequence to separate, detect, and capture the biomarker.

An optoelectronics system, built by ECE students Mike Wilkins and Ben Goodson, and an algorithm by Matt Sabo were key to the team's work identifying heart failure risk.

Taking a Closer Look at the Brain

In a partnership melding neuroscience and electrical engineering, researchers from UNC-Chapel Hill and NC State's Department of Electrical and Computer Engineering have developed a new technology that will allow neuroscientists to capture images of the brain almost 10 times larger than previously possible - helping them to better understand the behavior of neurons in the brain.

Nervous systems are complex. After all, everything that any animal thinks or does is controlled by its nervous system. To better understand how complex nervous systems work, researchers have used an expanding array of ever more sophisticated tools that allow them to actually see what's going on. In some cases, neuroscience researchers have had to create entirely new tools to advance their work.

This is how an electrical engineering researcher ended up co-authoring a Nature Biotechnology paper with a group of neuroscientists.

A UNC-Chapel Hill research team wanted to be able to look at "ensemble" neuronal activity related to how mice process visual input. In other words, they wanted to look at activity in neurons across multiple areas at the same time.

To do that, the researchers used a two-photon microscope, which images fluorescence. In this case, it could be used to see which neurons "light up" when active.

The problem was that conventional two-photon microscopy systems could only look at approximately one square millimeter of brain tissue at a time. That made it hard to simultaneously capture neuron activity in different areas.

This is where **Dr. Michael Kudenov** comes in. An assistant professor of electrical and computer engineering at NC State, Kudenov's area of expertise is remote imaging. His work focuses on developing new instruments and sensors to improve the performance of technologies used in everything from biomedical imaging to agricultural research.

After being contacted by the UNC researchers, Kudenov designed a series of new lenses for the microscope that were incorporated into an overall two-photon imaging system that allowed the researchers to scan much larger areas of the brain. Instead of capturing images covering one square millimeter of the brain, they could capture images covering more than 9.5 square millimeters.

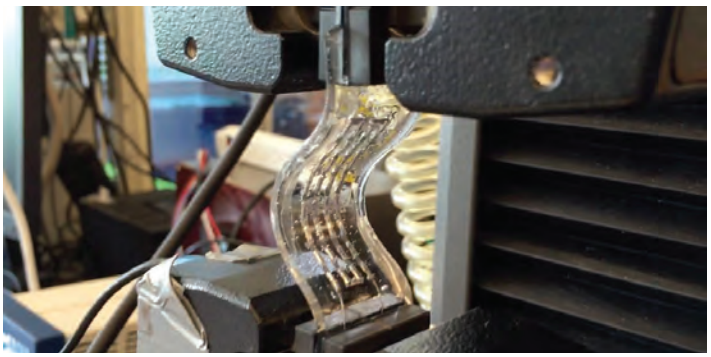
Improving Performance of Flexible Wearables

In a proof-of-concept study, electrical engineers at NC State have designed a flexible thermoelectric energy harvester that has the potential to rival the effectiveness of existing battery-powered wearable electronic devices using body heat as the only source of energy.

Wearable devices used to monitor a variety of health and environmental measures are becoming increasingly popular. The performance and efficiency of flexible devices, however, pale in comparison to rigid devices, which have been superior in their ability to convert body heat into usable energy.

"We wanted to design a flexible thermoelectric harvester that does not compromise on the material quality of rigid devices yet provides similar or better efficiency," said **Dr. Mehmet Ozturk**, a professor of electrical and computer engineering at NC State and corresponding author of a paper describing the work. "Using rigid devices is not the best option when you consider a number of different factors." Ozturk mentioned superior contact resistance - or skin contact - with flexible devices, as well as the ergonomic and comfort considerations to the device wearer.

Ozturk said that he and colleagues Dr. Michael Dickey (Chemical Engineering) and **Dr. Daryoosh Vashaee**, associate professor of electrical and computer engineering,



wanted to utilize the best thermoelectric materials used in rigid devices in a flexible package, so that manufacturers wouldn't need to develop new materials when creating flexible devices.

"We use a liquid metal of gallium and indium - a common, non-toxic alloy called EGaIn - to connect the thermoelectric 'legs,'" Ozturk said. "The electric resistance of these connections is very low, which is critical since the generated power is inversely proportional to the resistance: low resistance means more power.

"Using liquid metal also adds a self-healing function: If a connection is broken, the liquid metal will reconnect to make the device work efficiently again. Rigid devices are not able to heal themselves," Ozturk added.

Low-cost Wearable Skin Hydration Sensor

Researchers from NC State, including the Department of Electrical and Computer Engineering have developed a wearable, wireless sensor that can monitor a person's skin hydration for use in applications that need to detect dehydration before it poses a health problem. The device is lightweight, flexible and stretchable and has already been incorporated into prototype devices that can be worn on the wrist or as a chest patch.

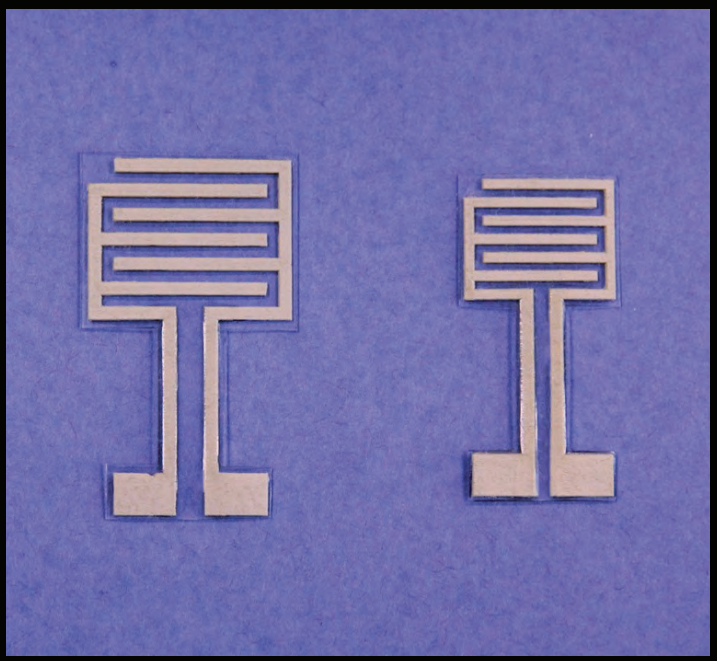
"It's difficult to measure a person's hydration quantitatively, which is relevant for everyone from military personnel to athletes to firefighters, who are at risk of health problems related to heat stress when training or in the field," says **Dr. John Muth**, a professor of electrical and computer engineering at NC State and co-corresponding author of a paper describing the work.

"We have developed technology that allows us to track an individual's skin hydration in real time," says Yong Zhu, an associate professor of mechanical and aerospace engineering at NC State and co-corresponding author of the paper.

> "Our sensor could be used to protect the health of people working in hot conditions, improve athletic performance and safety, and to track hydration in older adults or in medical patients suffering from various conditions. It can even be used to tell how effective skin moisturizers are for cosmetics."

The sensor consists of two electrodes made of an elastic polymer composite that contains conductive silver nanowires. These electrodes monitor the electrical properties of the skin. Because the skin's electric properties change in a predictable way based on an individual's hydration, the readings from the electrodes can tell how hydrated the skin is.

In lab testing using custom-made artificial skins with a broad range of hydration levels, the researchers found that the performance of the wearable sensor was not affected by ambient humidity. And the wearable sensors were just



as accurate as a large, expensive, commercially available hydration monitor that operates on similar principles, but utilizes rigid wand-like probes.

The researchers also incorporated the sensors into two different wearable systems: a wristwatch and an adhesive patch that can be worn on the chest. Both the watch and the patch wirelessly transmit sensor data to a program that can run on a laptop, tablet or smartphone. This means the data can be monitored by the user or by a designated third party - such as a doctor in a hospital setting, or an officer in a military setting.

What's more, the sensor is relatively inexpensive.

"The commercially available monitor we tested our system against costs more than $8,000," says Shanshan Yao, a Ph.D. student at NC State and lead author of the paper.

> "Our sensor costs about one dollar, and the overall manufacturing cost of the wearable systems we developed would be no more than a common wearable device, such as a Fitbit."

Over 100 Years of Doing the Coolest Things

1893 Electrical Engineering Begins

The first electrical engineering course—Electricity and Magnetism—is offered at the North Carolina College of Agriculture and Mechanic Arts, taught by Lt. Richard Henderson, U.S. Navy.

1917 EE Becomes a Department

Due to the growth of the two programs and diverging needs, Physics is separated from Electrical Engineering, marking the beginning of the Department of Electrical Engineering, headed by Professor William Hand Browne, Jr., who would lead the department until 1944.

1921 First Woman at NC State

Lucille Thomson became the first woman ever to enroll at NC State. She enrolled in electrical engineering.

1923 School of Engineering

The School of Engineering was formed, consisting of the Electrical Engineering Department, Civil Engineering Department, Physics Department, Textile Engineering, and Mechanical Engineering.

1936 Accreditation

The Electrical Engineering curricula is accredited by the Engineers' Council for Professional Development, now the Accreditation Board for Engineering and Technology (ABET).

1953 First African-American Student

The first African-American graduate students enrolled at NC State, including Robert L. Clemons in Electrical Engineering. He would become the first African-American to receive a degree from NC State in 1957.

1979 First Woman on Faculty

Dr. Sarah A. Rajala joined the Electrical Engineering faculty and became the first female Ph.D. faculty member to join the College of Engineering.

1981 Electrical & Computer

With the growth and influence of the modern computer, the department is renamed the Department of Electrical and Computer Engineering.

2017

100th Anniversary

The year marked the celebration of the 100th anniversary of the Department of Electrical and Computer Engineering. With growing promotional efforts, a brand-new website, and new facilities like the ECE MakerSpaces, the department put into action the celebration by setting the stage for the next hundred years.

2014

PowerAmerica

President Barack Obama and the U.S. Department of Energy tap NC State to lead a $140 million advanced manufacturing institute to unite academic, government and industry partners in an effort to revolutionize energy efficiency across a wide range of applications.

2012

ASSIST & FREEDM

The Advanced Self-Powered Systems of Integrated Sensors and Technologies (ASSIST) Center opens, joining the Future Renewable Electric Energy Delivery and Management Systems (FREEDM) Center, which started in 2008, marking the department as the country's only with two concurrent NSF centers.

1997

Move to Centennial Campus

Starting with Monteith Research Center, the department begins to move to the new Centennial Campus. In 2005, the move from Daniels Hall is completed with the opening of Engineering Building II.

1982

First NSF Center

Dr. J. Benjamin O'Neal established the first NSF research center in the department: The Center for Communications and Signal Processing, sponsored by the National Science Foundation, establishing a persisting pattern of cutting edge research in the department.

New Manufacturing Process for SiC Power Devices

Researchers from North Carolina State University are rolling out a new manufacturing process and chip design for silicon carbide (SiC) power devices, which can be used to more efficiently regulate power in technologies that use electronics. The process - called PRESiCE™ - was developed with support from the PowerAmerica Institute funded by the U.S. Department of Energy to make it easier for companies to enter the SiC marketplace and develop new products.

"PRESiCE™ will allow more companies to get into the SiC market, because they won't have to initially develop their own design and manufacturing process for power devices - an expensive, time-consuming engineering effort," says **Dr. Jay Baliga**, Distinguished University Professor of Electrical and Computer Engineering at NC State and lead author of a paper on PRESiCE™ that was presented in September. "The companies can instead use the PRESiCE™ technology to develop their own products. That's good for the companies, good for consumers, and good for U.S. manufacturing."

The power devices consist of a diode and transistor, and are used to regulate the flow of power in electrical devices. For decades, electronics have used silicon-based power devices. In recent years, however, some companies have begun using SiC power devices, which have two key advantages.

First, SiC power devices are more efficient, because SiC transistors lose less power. Conventional silicon transistors lose ten percent of their energy to waste heat. SiC transistors lose only seven percent. This is not only more efficient, but means that product designers need to do less to address cooling for the devices.

Second, SiC devices can also switch at a higher frequency. That means electronics incorporating SiC devices can have smaller capacitors and inductors - allowing designers to create smaller, lighter electronic products.

But there's a problem. Up to this point, companies that have developed manufacturing processes for creating SiC power devices have kept their processes proprietary - making it difficult for other companies to get into the field. This has limited the participation of other companies and kept the cost of SiC devices high.

> NC State researchers developed PRESiCE™ to address this bottleneck, with the goal of lowering the barrier of entry to the field for companies and increasing innovation.

The PRESiCE™ team worked with a Texas-based foundry called X-Fab to implement the manufacturing process and have now qualified it - showing that it has the high yield and tight statistical distribution of electrical properties for SiC power devices necessary to make them attractive to industry.

Right now, SiC devices cost about five times more than silicon power devices.

"Our goal is to get it down to 1.5 times the cost of silicon devices," Baliga says. "Hopefully that will begin the 'virtuous cycle': lower cost will lead to higher use; higher use leads to greater production volume; greater production volume further reduces cost, and so on. And consumers are getting a better, more energy-efficient product."

The researchers have already licensed the PRESiCE™ process and chip design to one company, and are in talks with several others.

"I conceived the development of wide bandgap semiconductor (SiC) power devices in 1979 and have been promoting the technology for more than three decades," Baliga says. "Now, I feel privileged to have created PRESiCE™ as the nation's technology for manufacturing SiC power devices to generate high-paying jobs in the U.S. We're optimistic that our technology can expedite the commercialization of SiC devices and contribute to a competitive manufacturing sector here in the U.S."

Streaming on a Wireless Power Connection

Researchers from North Carolina State University's Department of Electrical and Computer Engineering have developed a system that can simultaneously deliver watts of power and transmit data at rates high enough to stream video over the same wireless connection. By integrating power and high-speed data, a true single "wireless" connection can be achieved.

"Recently wireless power as re-emerged as a technology to free us from the power cord," says **Dr. David Ricketts**, an associate professor of electrical and computer engineering at NC State and senior author of a paper on the work. "One of the most popular applications is in wireless cell phone charging pads. As many know, these unfortunately often require almost physical contact with the pad, limiting the usefulness of a truly 'wireless' power source. Recent work by several researchers have extended wireless power to 'mid-range' which can supply power at inches to feet of separation. While encouraging, most of the wireless power systems have only focused on the power problem - not the data that needs to accompany any of our smart devices today. Addressing those data needs is what sets our work apart here."

Wireless power transfer technologies use magnetic fields to transmit power through the air. To minimize the power lost in generating these magnetic fields, you need to use antennas that operate in a narrow bandwidth - particularly if the transmitter and receiver are inches or feet apart from each other.

Because using a narrow bandwidth antenna limits data transfer, devices incorporating wireless power transfer have normally also incorporated separate radios for data transmission. Having separate systems for data and power transmission increases the cost, weight and complexity of the relevant device.

The NC State team realized that while high-efficiency power transfer, especially at longer distances, does require very narrow band antennas, the system bandwidth can actually be much wider.

"People thought that efficient wireless power transfer requires the use of narrow bandwidth transmitters and receivers, and that this therefore limited data transfer," Ricketts says.

> "We've shown that you can configure a wide-bandwidth system with narrow-bandwidth components, giving you the best of both worlds."

With this wider bandwidth, the NC State team then envisioned the wireless power transfer link as a communication link, adapting data-rate enhancement techniques, such as channel equalization, to further improve data rate and data signal quality.

The researchers tested their system with and without data transfer. They found that when transferring almost three watts of power - more than enough to power your tablet during video playback - the system was only 2.3 percent less efficient when also transmitting 3.39 megabytes of data per second. At two watts of power, the difference in efficiency was only 1.3 percent. The tests were conducted with the transmitter and receiver 16 centimeters, or 6.3 inches, apart, demonstrating the ability of their system to operate in longer-distance wireless power links.

"Our system is comparable in power transfer efficiency to similar wireless power transfer devices, and shows that you can design a wireless power link system that retains almost all of its efficiency while streaming a movie on Netflix," Ricketts says.

AWARDS

Muth becomes Jefferson Science Fellow

Dr. John F. Muth, a professor of electrical and computer engineering at NC State, has been selected for the thirteenth class of Jefferson Science Fellows (JSF).

Dr. Muth was selected in December 2016 and began his one-year assignments in Washington, D.C. in August 2017.

The Jefferson Science Fellows Program is designed to further build capacity for science, technology, and engineering expertise within the U.S. Department of State and U.S. Agency for International Development (USAID).

Established in 2003, the program established a new model for engaging the American academic science, technology, engineering, and medical communities in the formulation and implementation of U.S. foreign policy and international development programming.

Baliga Named Fellow of National Academy of Inventors

Dr. B. Jayant Baliga, Distinguished University Professor of electrical and computer engineering has been named a fellow by the National Academy of Inventors (NAI).

He was nominated by his peers for outstanding contributions to innovation in areas such as patents and licensing, innovative discovery and technology, significant impact on society, and support of innovation.

The 2016 Fellows were inducted on April 6, 2017, as part of the Sixth Annual Conference of the National Academy of Inventors in Boston, MA.

Baliga is a prolific inventor in the field of power semiconductor devices with 120 U.S. Patents issued to him, many of which have been commercialized by his four start-up companies. His most famous invention is the Insulated Gate Bipolar Transistor. Its extensive applications in all sectors of the world-wide economy have saved consumers $23.7 trillion and reduced carbon dioxide emissions by 109 trillion pounds during the last 25 years.

Dai and Wang Elevated to IEEE Fellow

Two NC State electrical and computer engineering professors began the New Year being honored with elevation to Institute of Electrical and Electronic Engineers (IEEE) Fellow in recognition of their ongoing contributions to the field. **Dr. Huaiyu Dai** was chosen for his contributions to multiple input, multiple output (MIMO) communications and wireless security, and **Dr. Wenye Wang** for her contributions to modeling and performance evaluation of wireless networks.

The IEEE Grade of Fellow is conferred by the IEEE Board of Directors upon persons with an outstanding record of accomplishments in any of the IEEE fields of interest. The total number selected in any one year cannot exceed one-tenth of one percent of the total voting membership.

IEEE Fellow is the highest grade of membership and is recognized by the technical community as a prestigious honor and an important career achievement.

"Becoming an IEEE Fellow is a particular honor since it is the result of peers recognizing the significance and impact of one's contributions," said Dr. Daniel Stancil, the ECE Department Head, "It also reflects well on the Department and University by demonstrating once again that our faculty and students are involved in innovative and cutting-edge research."

Steer Awarded Holladay Medal

Three NC State professors, including **Dr. Michael B. Steer** from the Department of Electrical and Computer Engineering, received the Alexander Quarles Holladay Medal for Excellence, the highest faculty honor bestowed by NC State University and the Board of Trustees.

The Holladay Medal is named for Col. Alexander Quarles Holladay, the university's first president. It recognizes career contributions of faculty members in teaching, research and service. Winners receive a medal and a framed certificate, and their names are inscribed on a plaque in the NC State Faculty Senate chambers.

Steer, a Lampe Distinguished Professor, is a Fellow of the Institute of Electrical and Electronic Engineers. He is a 1987 Presidential Young Investigator (USA) and was awarded the Bronze Medallion by U.S. Army Research for "Outstanding Scientific Accomplishment" in 1994 and 1996.

He received the Alcoa Foundation Distinguished Research Award from North Carolina State University in 2003, and was the Jack S. Kilby Lecturer that same year. He was Editor-In-Chief of the society's flagship publication the IEEE Transactions on Microwave Theory and Techniques from 2003 to 2006. Steer received Service Recognition Awards from the IEEE Microwave Theory and Techniques Society in 1998 and in 2001, and a Distinguished Service Award from the Society in 2007.

O'Neal Receives Friday Award

Dr. Ben O'Neal, Professor Emeritus in the Department of Electrical and Computer Engineering was honored in May 2017 with the Friday Award, recognizing his continuing teaching excellence in retirement. The Friday Award, named in honor of UNC System President Emeritus William C. Friday, recognizes exemplary accomplishments and contributions made during retirement. O'Neal continues a course he created that prepares engineering students to become Registered Professional Engineers and has a passion for engineering registration. Additionally, he is a great role model for students in competence, character, and professionalism.

"When Ben first started teaching for our program, he caught my attention because he modeled the lifelong learning behavior that we hope our members will embrace. Our program is all about 'second acts' and making sure continuing education is not just for the working years," explained Osher Lifelong Learning Instutute Director Tricia Inlow-Hatcher.

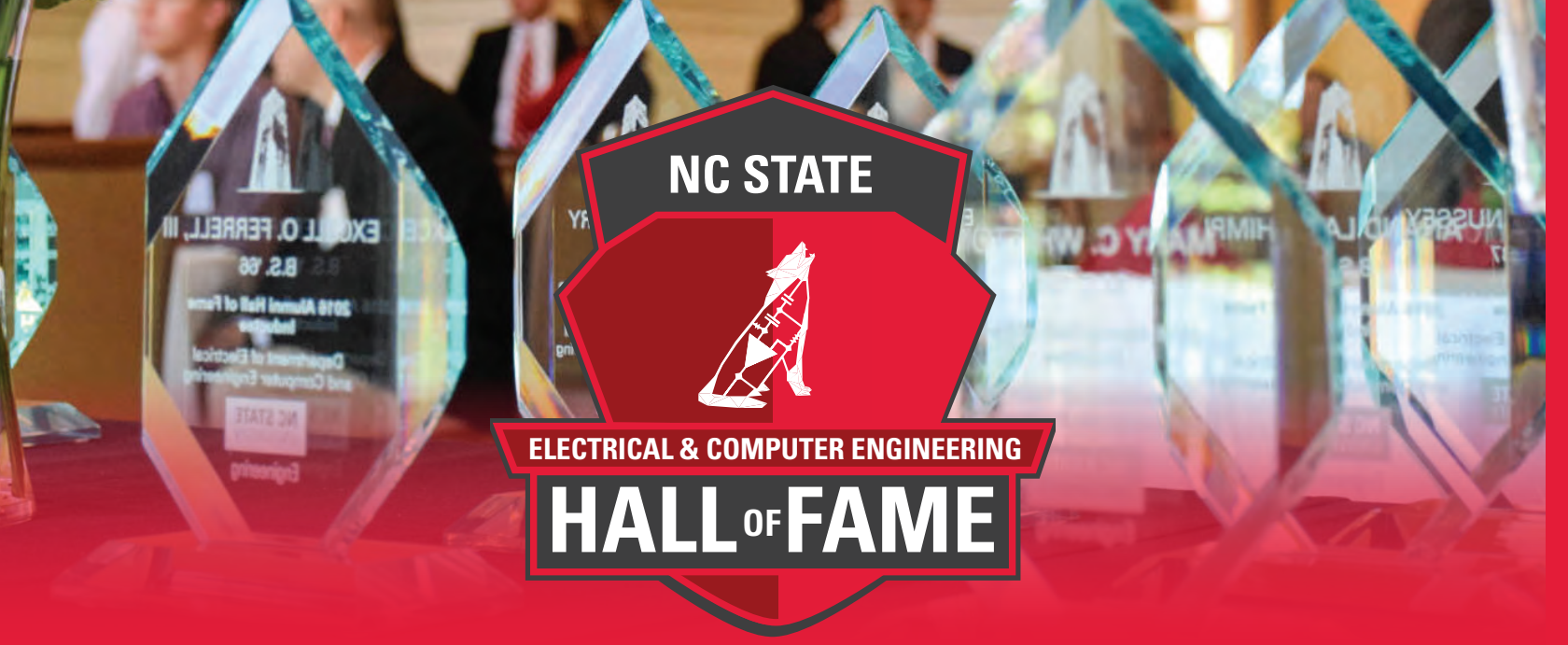
Veliadis becomes IEEE EDS Distinguished Lecturer

Dr. Victor Veliadis, professor of electrical and computer engineering and CTO of the PowerAmerica Institute, based at NC State, has been honored as a Distinguished Lecturer for the IEEE Electron Devices Society.

The purpose of the IEEE EDS Distinguished Lecturer Program is to have well-known educators and researchers provide quality lectures and host technical meetings.

Veliadis has authored over 100 peer-reviewed technical articles, three book chapters, and has 24 issued patents to his credit.

The PowerAmerica Institute, backed by the U.S. Department of Energy, is accelerating the adoption of advanced semiconductor components made with silicon carbide and gallium nitride into a wide range of products and systems.



NC STATE
ELECTRICAL & COMPUTER ENGINEERING
HALL OF FAME

The Department of Electrical and Computer Engineering at NC State University is proud to announce the 2017 inductees to the **ECE Alumni Hall of Fame**. The purpose of this extraordinary honor is to celebrate the accomplishments of our outstanding graduates who have used their education to excel in a profession, career, or service. Additionally, this recognition will serve as an inspiration for current students.

Our alumni are at the core of the Department, representing the agents and ambassadors that have made groundbreaking contributions in the study of electrical and computer engineering and beyond.

2015 Inductees

Dr. Tülay Adali
Mr. Greg E. Bottomley
Dr. Laura J. Bottomley
Mr. Joseph S. Colson, Jr.
Mr. Wesley B. Covell
Mr. William H. Dean
Mr. John M. Eubanks
Mr. Cataldo U. Falco
Dr. Edward D. Graham, Jr.
Ms. Christina M. Hammock
Dr. John R. Hauser
Mr. Clayton Scott Hinnant
Mr. Irwin R. Holmes
Dr. J. Stuart Hunter
Dr. Michael A. Littlejohn
Mr. Robin E. Manning
Mr. Stephen H. Marbut
Dr. John S. Mayo
Mr. Thomas R. McPherson, Jr.
Mr. Darrell V. Menscer
Dr. Tony L. Mitchell
Dr. Larry K. Monteith
Mr. Sharat Nagaraj
Mr. Sanjay Nayak
Mr. Billy B. Oliver
Mr. Larry Nixon
Dr. John L. Prince, III
Ms. Deborah S. Proctor
Dr. Jason P. Rhode
Dr. Wesley E. Snyder
Mr. Jim Stritzinger
Mr. William F. Troxler
Dr. J. Turner Whitted
Mr. Scot Wingo

2016 Inductees

Mr. Gregory L. Booth
Mr. Earl "Skip" Booth III
Dr. Tom Bradicich
Dr. Charles L. Britt, Jr.
Dr. P. Mark Buff III
Mr. Mark Carter
Dr. Christos Christodoulou
Dr. Edward Randy Collins, Jr.
Mr. Marion Casey Dean
Mr. Lynn W. Eury
Mr. Excell O. Ferrell III
Lt. Gen. Buster C. Glosson
Mr. Craig Ivey
Dr. Shree K. Nayar
Mr. William Nussey
Mr. Anand Lal Shimpi
Ms. Mary C. Whitton
Dr. Steven A. Wright

2017 Inductees

Dr. April S. Brown
Professor of Electrical and Computer Engineering, Duke University
B.S. EE 1981

Dr. Teresa A. Dahlberg
Dean of the College of Engineering and Computer Science, Syracuse University
M.S. CPE 1990, Ph.D. CPE 1993

Dr. Michael Devetsikiotis
Chair of Electrical and Computer Engineering, The University of New Mexico
M.S. EE 1990, Ph.D. EE 1993

Dr. Wesley O. Doggett
Professor Emeritus, Department of Physics, North Carolina State University
B.S. EE 1953
Awarded Posthumously

Dr. Oscar N. Garcia
Founding Dean of Engineering, University of North Texas, 2003-2008
B.S. EE 1961, M.S. EE 1964

Mr. Paul L. Madren, Jr.
Engineering Scientist, IBM (Ret.)
B.S. EE 1959

Dr. Robert J. Mattauch
Dean Emeritus, School of Engineering, Virginia Commonwealth University
M.S. EE 1964, Ph.D. EE 1967

Mr. Dan Page
Vice President of Research and Development, Synopsys, Inc.
B.S. EE 1985

Dr. Alice C. Parker
Dean's Professor of Electrical Engineering, University of Southern California
B.S. EE 1970, Ph.D. EE 1975

Mr. Nelson Peeler
Senior Vice President and Chief Transmission Officer, Duke Energy
B.S. EE 1988

Dr. Hairong Qi
Gonzalez Family Professor in Image Processing, The University of Tennessee Knoxville
Ph.D. CPE 1999

Mr. James R. Schofield
Program Manager, Boeing (Ret.)
B.S. EE 1959

Read more at **go.ncsu.edu/HallOfFame**

M.C. Dean Distinguished Professorship

William "Bill" H. Dean (EE '88), president and CEO of M.C. Dean, Inc., and his father, Marion Casey Dean (EE '67), current chairman of the company's Board of Directors, have established two professorship funds: the endowed M.C. Dean, Inc. Distinguished Professorship in Electrical and Computer Engineering and the M.C. Dean, Inc. Term Professorship in Electrical and Computer Engineering.

The company, headquartered in Tysons, VA is a global leader in power engineering, applied electronics, information technology, controls systems, software, and systems integration for local and federal governments, corporate and institutional clients. They specialize in mission-critical projects, including Washington National Airport, Bolling Air Force Base and the Naval Research Laboratory.

Marion Caleb Dean started M.C. Dean, Inc. in 1949 as an electrical speciality contracting business.

Casey Dean knew he wanted to be an electrical engineer and entered NC State in 1963. "The first time I walked on campus I knew this was where I wanted to spend my four years. The electrical engineering professors I had were very important to me. I respected the heck out of those guys," he said. As early as 1952, M.C. Dean, Inc. started an electrical apprenticeship program. In the 1970s, Casey Dean continued his father's effort with two electrical apprenticeship programs whose graduates included women and minorities.

These programs continue today, along with several other programs that Bill Dean, president and CEO, has instituted such as the M.C. Dean, Inc. Scholarship Program and the M.C. Dean Foundation. Casey Dean joined the NC State Engineering Foundation Board of Directors in 2016 and Bill Dean served on the Board as recently as 2015.

Dr. Daniel Stancil explained the significance of these gifts, "The M.C. Dean professorships are extremely important for the ECE Department and having them allows us to take advantage of opportunities to bring world-class senior faculty to NC State. These resources enable new possibilities for our hiring this year, and it is possible that we will be able to award the term professorship as early as fall 2018."

"In talking to Dr. Stancil," Bill Dean explained, "we went through all the (research) areas—Cyber Physical systems and the Internet of Things are square down the center of the future of our organization."

Bennett Family Legacy

Mrs. Alice B. Bennett

Mrs. Alice B. Bennett, the mother of Mr. R. Ray Bennett, endowed a faculty fellowship for the NC State Department of Electrical and Computer Engineering as a memorial to her son.

Mr. R. Ray Bennett received his B.S. degree in electrical engineering from NC State in 1964. Ray was a Raleigh native and graduated from Broughton High School. Both his mother and father had strong NC State connections going back three generations, so it was an easy decision for Ray to pursue his engineering studies at NC State. Mr. Bennett worked most of his career at MeadWestvaco Co. and was stationed at their North Charleston plant, where he worked as an electrical engineer.

In 2012, Mr. Bennett passed away well before his time. His original intent to create the R. Ray Bennett Faculty Fellows Fund through his estate plans, would provide a permanent resource for high achieving young faculty in the Department of Electrical and Computer Engineering at NC State in pursuing their academic and research initiatives.

Mrs. Bennett was keen to make sure her son's plans would be successful, and her generous gift will enhance the department's ability to support the success of new faculty members.

Kolbas and Troxler MakerSpaces

In late 2016, the Department of Electrical and Computer Engineering opened the ECE MakerSpace in Engineering Building II, consisting of two facilities – the Robert M. Kolbas MakerSpace, and the William F. Troxler MakerSpace. The two spaces serve to provide all of the resources students need to realize electronics and fabrication projects, both for Senior Design and other coursework as well as extracurricular and personal experimentation and creation.

Dr. Robert M. Kolbas a professor of electrical and computer engineering since 1985 has published more than 140 manuscripts in refereed journals. He has pioneered hands-on laboratory experiences for undergraduates and encourages them to invent, tinker, explore, and discover how to realize their dreams in the MakerSpace.

The Troxler ECE MakerSpace was made possible with a gift from Mr. Troxler's son, Dr. Robert E. Troxler, a long-time supporter, friend and alumnus of the department, to honor his father, a Distinguished Engineering Alumnus and also a generous benefactor of the College of Engineering.

The MakerSpace will enable and encourage students to be involved in hands-on engineering projects in their coursework and of personal interest. The ECE Department expresses its sincere gratitude to Dr. Kolbas and Dr. Troxler for their generosity that made the ECE MakerSpace possible!

Dr. Griff L. Bilbro (1948-2016)

Dr. Griff L. Bilbro, a professor of electrical and computer engineering at North Carolina State University passed away unexpectedly on November 10, 2016. Dr. Bilbro obtained his Bachelor's degree in Physics from Case Western and went on to the University of Illinois at Urbana-Champaign in 1975 to obtain his Masters in Physics and a PhD from Illinois in 1977.

Dr. Bilbro taught at N.C. State since 1985, spending 31 years training young engineers to excel. He had an outstanding teaching record at NC State; in 2001 he was elected to be a part of the NC State Academy of Outstanding Teachers and he was named the IEEE Undergraduate Teacher of the Year in 2006.

His interests were broad— from phase transitions and image processing to modeling transitions. Dr. Bilbro pledged his support to both NC State students and faculty and influenced students to follow their dreams.

He enjoyed teaching and many current students and alumni remember his classes fondly, emphasizing his ability to find the humor in a situation and keep a smile on his face.

Dr. Bilbro left a lasting impact on the Wolfpack family, and our hearts continue to go out to his wife, Dr. Carla Savage, a professor of Computer Science at NC State and their family.

NC STATE UNIVERSITY

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Support ECE

A gift to the Department of Electrical and Computer Engineering is an investment in the future.

Through generous alumni, corporate partners and friends, the Department has been able to create new education opportunities, develop new research and technologies and attract the brightest faculty and students.

To learn more about supporting the Department, contact the NC State Engineering Foundation.

ece.ncsu.edu/donate