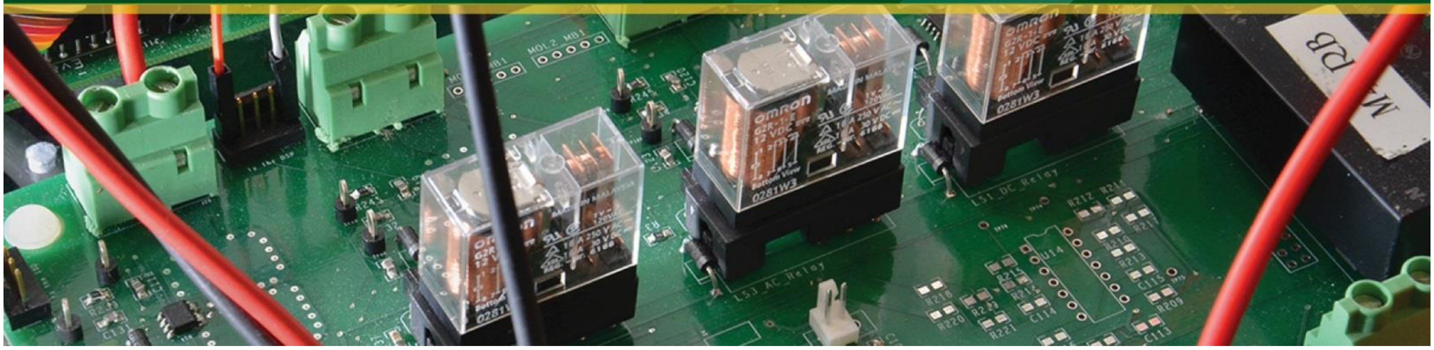
UNC CHARLOTTE

Electrical And Computer Engineering

The William States Lee College of Engineering

Newsletter Fall 2017



Asis Nasipuri, Chair

Dear Friends:

I am pleased to share with you the 2016-17 Newsletter from ECE at UNC Charlotte, which includes some highlights from the past academic year.

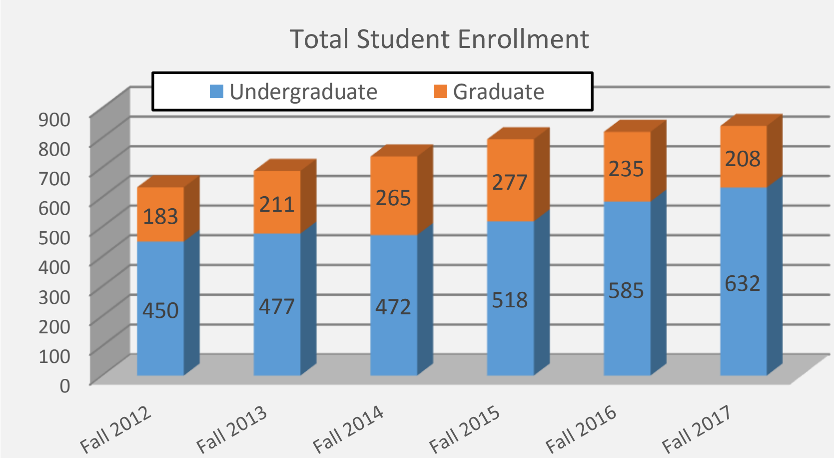
Enrollments in ECE's undergraduate programs increased for the third consecutive year, resulting in more than 33% increase in the total UG enrollment over the past three years. The total student enrollment in the department is 840 this fall, which includes 632 undergraduate and 208 graduate students.

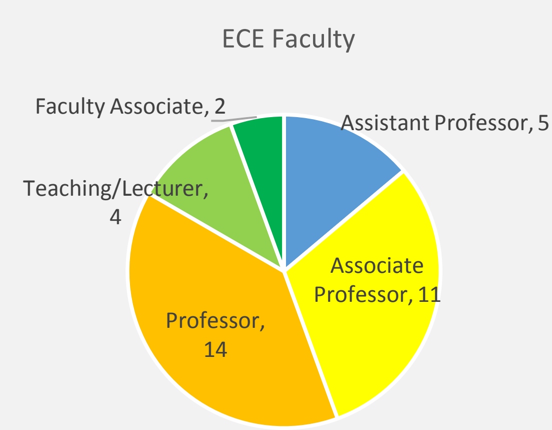
We are also excited to welcome three new faculty members this year, bringing the department to 36 full time faculty members. This includes Mike Mazzola, who joined as the Director of the Energy Production and Infrastructure Center (EPIC) and Professor of ECE, and two faculty members in computer engineering, which is an area of increasing interest. The profiles of these faculty members are provided below.

Dr. Yong Zhang was named a *2017 Fellow of the American Physical Society*. Dr. Robert Cox won the College of Engineering *Undergraduate Teaching Award*. ECE faculty members won over 31 research grants in 2016-2017, bringing in close to $2.5M of external research funding over this period. The current year looks more promising, with over $1.2M of new research awards won by ECE faculty between July to September, 2017.

Thank you for your interest in the ECE Department at UNC Charlotte.

Kind regards





Faculty Highlights

Dr. Yong Zhang named APS Fellow

Dr. Yong Zhang, Bissell Distinguished Professor of Electrical and Computer Engineering, was elected as a 2017 Fellow of the American Physical Society (APS). This distinction for Dr. Zhang was based on the recommendation of the Forum on Industrial Applied Physics (FIAP). The APS citation recognizes Dr. Zhang for his outstanding contributions to the fundamental understanding, characterization and applications of semiconductor hetero-structures and isoelectronic impurities in semiconductors. The APS elects no more than one half of one percent of the membership by their peers for this prestigious recognition.

Dr. Zhang joined UNC Charlotte as the Bissell Distinguished Professor of Engineering in 2009. He is also a member of the Optical Science and Engineering Program and the Nanoscale Science Ph.D. program at UNC Charlotte. Prior to joining UNC Charlotte, Dr. Zhang was a Senior Scientist at NREL. His research interests include emerging and future generation materials and device architectures for energy and related applications (photovoltaics, solid-state-lighting, detector); fundamental sciences in solid state physics and electrical engineering; optical spectroscopy and material growth; large scale first-principles and empirical electronic structure modeling. He has published over 210 technical articles on his work with an H-index of 38.

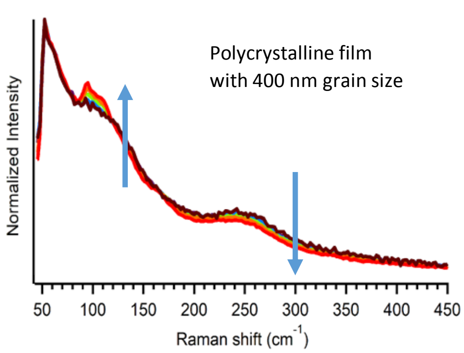
Dr. Robert Cox wins COE Undergraduate Teaching Award

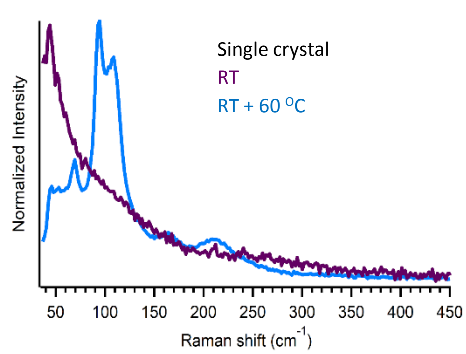
Dr. Robert Cox, Associate Professor of ECE, is the winner of the 2016-2017 Excellence in Undergraduate Teaching Award in the Williams States Lee College of Engineering. Dr. Cox is a passionate and effective teacher and is a top choice for many ECE students. He is known to hold high standards but is widely appreciated for his teaching style. He teaches a wide range of courses in ECE that include sophomore level courses such as Network Theory I and II; junior level Industrial Electronics and Junior Design; senior level courses such as Digital Signal Processing, Random Processes, and Electrical Machinery; as well as graduate level courses such as Dynamics and Control of AC Drives and Power Electronic Design. His course on Energy Analytics, which he has been teaching for the past few years as part of his efforts on sustainable buildings, fills up very quickly. To date, Dr. Cox supervised 10 Ph.D. students and over 15 Master's students for their research dissertations and theses. In addition, Dr. Cox routinely involves a large number of undergraduate students in his research. Dr. Cox's excellence in teaching has also been recognized by the IEEE Region 3 Outstanding Educator Award in 2014.

Research Highlights

Stability Study of Emerging PV Materials

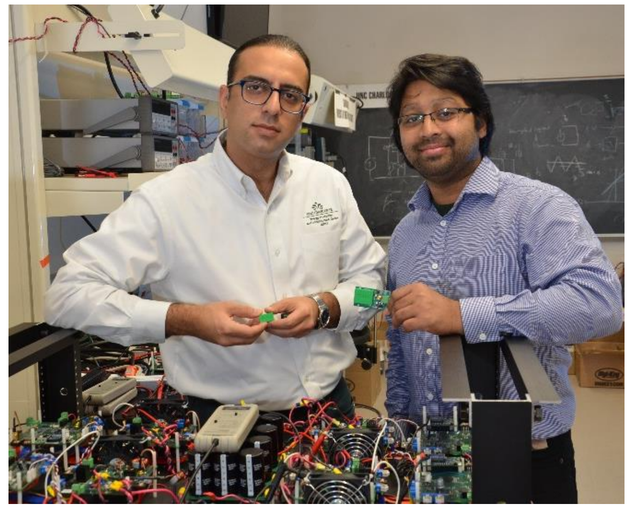
Organic-inorganic halide perovskites (e.g., MAPbX3, MA= CH3NH3) emerged only a few years ago as promising candidate materials for low-cost efficient solar cells and various other optoelectronic applications. In the past, it typically took several decades of research efforts for other materials to reach a performance target ready for commercialization. In contrast, within 6 years, the efficiency of low-cost solution processed perovskite solar cells has reached 22%, a milestone only a few materials has reached. However, a formidable challenge is the poor stability of these devices due to both intrinsic and extrinsic mechanisms that are not yet adequately understood. Prof. Yong Zhang's group, in collaboration with scientists in Korea, China, and NREL, has reported (in Phys. Rev. X) a





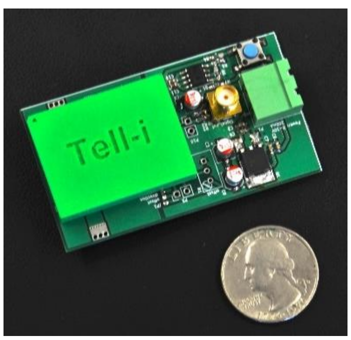
multiple stage structure transformation in an effort attempting to understand both ground and photo-excited states stability of this material. He is a co-PI on a new UNC Research Opportunities Initiative project "Hybrid Perovskite Materials and Technologies" in which his group and collaborators at UNC-CH, NCSU, and NCCU will continue the effort to understand the intrinsic and extrinsic mechanisms of the instability, and develop mitigation methods. As shown below, his group has shown how increasing laser power or temperature makes the Raman spectrum of the perovskite evolving from a practically featureless to one showing multiple well resolved peaks of PbI_2. His group is also interested in other types of hybrid materials, such as II-VI based hybrid nanostructures that have been shown to exhibit many unusual physical properties, such as room temperature free exciton emission and zero thermal expansion. These two families of organic-inorganic hybrid materials are complementary in sciences and applications.

Ultrafast Current Sensors for High Frequency Power Electronics



Power Electronics is undergoing a promising transition. Starting from line frequency power converters, we now have access to wide bandgap semiconductor power devices that enable high frequency power electronics systems. These systems would have unprecedented performance compared to conventional silicon-based power electronics in terms of power density, efficiency, and control bandwidth. One of its many challenges is the lack of current sensors for high voltage power electronics systems that are optimized to operate beyond 1 MHz. Dr. Babak Parkhideh and his research team in the Electrical and Computer Engineering Department at the University of North Carolina Charlotte address the need for such current sensors.

"We are interested to develop nonintrusive current sensing solutions with very high slew rate and frequency bandwidth characteristics, which is much needed for very high frequency power converters." Parkhideh said.



Parkhideh's team is investigating materials and techniques that respond to the magnetic field produced by the current in a printed circuit board trace. The research addresses the challenges of measurements due to asymmetrical current distribution and significantly non-uniform magnetic field around the trace at frequencies beyond 1 MHz. The approach is to properly shape and amplify the magnetic field with non-invasive Magnetic field CONcentrators (MCON) and active filtering.

"So far, we have achieved a very promising result of DC-10MHz bandwidth and more than 100 A/µS response for ±20A current; an order of magnitude improvement over the current state-of-the-art solutions. We have considered many practical issues including the presence of unwanted electromagnetic noises in fast switching power circuits. We believe we can enhance the performance to 30 MHz," Parkhideh said.

Hybrid High Voltage AC/DC System Protection and Controls for Interfacing Off-shore Power Generations with On-shore Grid

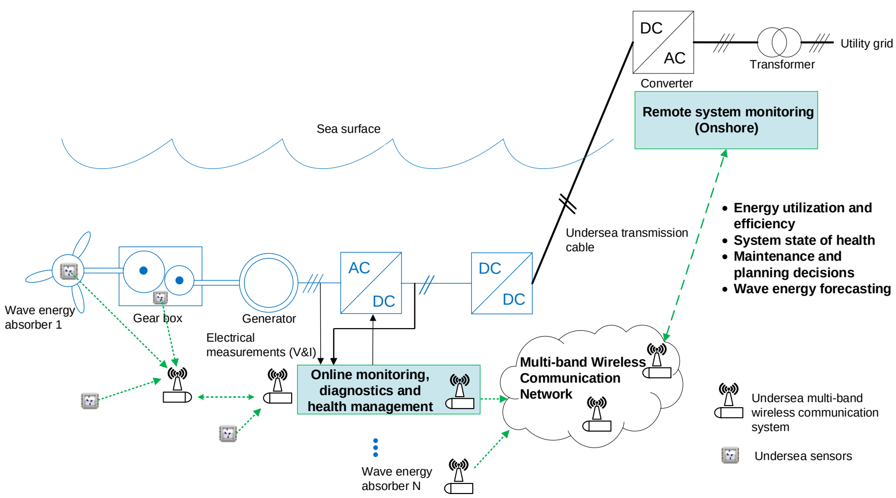
Drs. Madhav Manjrekar and Badrul Chowdhury have received funding from the NC Coastal Studies Institute to investigate the use of Multi-terminal High Voltage DC (MT-HVDC) transmission link based on Voltage Source Converter (VSC) technology for transferring power generated in off-shore wind farms. These MT-HVDC systems suffer from poor protection and control issues which stems from an inadequate understanding of the system-level power flow mechanisms and operation of such systems under fault and abnormal conditions. Furthermore stability aspects of such systems when subject to wind/tidal current variation and transient faults has not been fully addressed. Although, the US has very limited off-shore wind power production, there are a number of studies being funded by the US Department of Energy (see https://energy.gov/eere/wind/offshore-wind-research-and-development).

The principal objective of this project is to model and simulate an off-shore multi-terminal HVDC system along with the on-shore HVAC system and investigate system-wide power flow scenarios along with response of such system during abnormal operating circumstances and post-fault conditions in both ac and dc sections. Rather than employing a separate AC system protection scheme that gets patched with a DC system protection scheme, a combined model that includes power converters, power system controls and AC/DC protection methodology will be developed. This alternative offers advantages of adopting a holistic approach thereby accounting for interdependencies between the off-shore power production, the high voltage DC link between off-shore and on-shore, and the traditional high voltage AC grid that is on-shore.

Wave Energy Monitoring and Health Management Using Underwater Wireless Communication Network

Dr. Tiefu Zhao and Dr. Tao Han have received funds from the UNC Coastal Studies Institute to investigate a wave energy monitoring and health management platform using underwater wireless communication network. Ocean waves, tides and currents offer significant potential for electrical power generation. The development of ocean energy technology is a critical step in the expansion of our nation’s energy portfolio. Energy monitoring, fault diagnostics and health management are critical for wave energy systems to maintain safety, reliability, efficiency, and uptime.

The goal of this project is to improve the reliability and visibility of wave energy harvesting systems, and thus significantly enhance its performance and reduce its maintenance cost. The project will pioneer a holistic wave energy monitoring, diagnostics and health management platform using underwater wireless communication network. The team will investigate the physical model based signature analysis and advanced diagnostic algorithms to improve the system reliability. The project will also develop a multi-band underwater wireless communication system for reliable communication of the monitoring and diagnostic data. The proposed platform will allow the different types of sensors to communicate data (such as water temperature, speed, pressure, vibration, etc.) in addition to the electrical signals, therefore enable more accurate assessment, planning and forecasting of the irregular wave energy to create a reliable system that is economically viable at the same time.

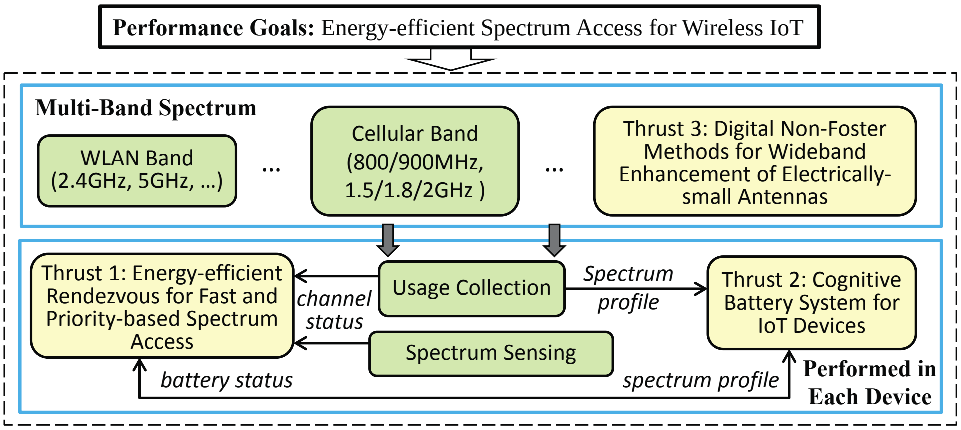


Online and remote wave energy monitoring and health management platform

Intelligent Energy Efficient Spectrum Access for Wireless IoT

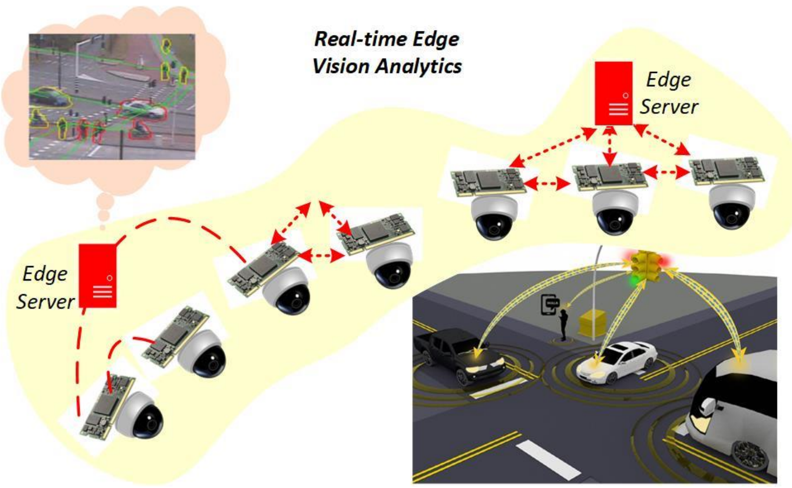
ECE faculty Drs. Jiang (Linda) Xie, Tao Han, and Thomas Weldon, received a three-year $600,000 grant from the National Science Foundation for the project “Intelligent Energy Efficient Spectrum Access for Wireless IoT.” The future Internet of Things (IoT) will support numerous types of applications producing overwhelming data traffic with highly different Quality-of-Service (QoS) requirements, creating challenges in terms of spectrum scarcity, and prohibitive energy consumption of billions of devices. This research offers transformative advances in overall network energy efficiencies, by leveraging order-of-magnitude energy efficiencies of low-frequency bands, novel heterogeneous battery management, and spectrum access methods designed to take advantage of these two new advances. This project will investigate: (1) energy-efficient spectrum access techniques with adaptive power management; (2) cognitive battery system to maximize the energy efficiency of each IoT device; and (3) digital non-Foster antennas for "Green IoT".

This research is truly interdisciplinary covering integrating advances in circuits/hardware design, device battery management, and synergistic energy-efficient networking and spectrum access. This research will generate innovative



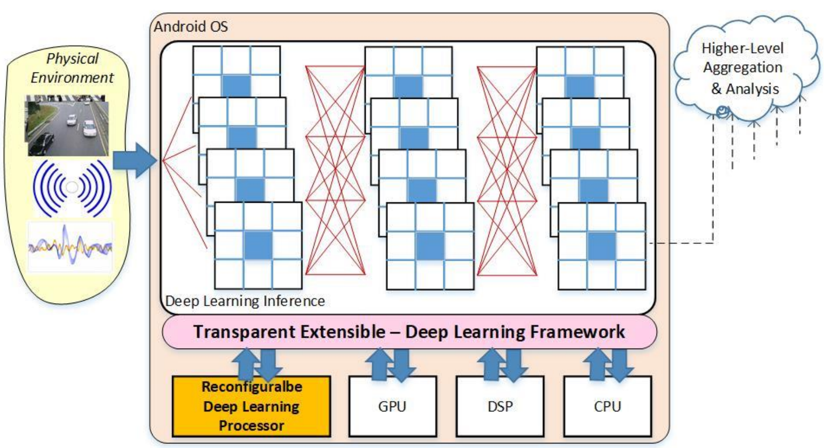
techniques to serve numerous applications of IoT technologies, e.g., smart cities and smart homes, mobile health, and intelligent transportation systems. It will also greatly advance the understanding of energy efficiency of IoT devices and networks.

Pedestrian Safe and Secure Communities with Ambient Machine Vision



This project led by Dr. Hamed Tabkhivayghan, is in cooperation with the Charlotte-Mecklenburg counties addresses community challenges of pedestrian safety and community policing, building on advances in cyber-physical systems (CPS). As communities adopt technologies such as vision-based traffic cameras and smart traffic signs at intersections, the data from these technologies possess traces of the activity within a community of which a few might need a response because of risk to individual and public safety or suggest a local police response. Such technologies may provide a more accurate community-wide operational picture. With this data, communities can have a better understanding of itself and within established law and custom will better serve and protect individuals and the public at large. This grant will enable community planners, local government, and businesses along with technologists, urban planners and traffic engineers to explore the potential of these emerging technologies for improving the quality of life of a community. Others involved in the project are Dr. Arun Ravindran of Electrical and Computer Engineering, Dr. Shannon Reid of Criminal Justice and Criminology, and Dr. Srinivas Pulugurtha of Civil and Environmental Engineering.

Real-Time Deep Learning Inference on the Edge



Dr. Hamed Tabkhivayghan is also leading a project on deep learning. This project aims to build an ultra-efficient real-time deep learning inference at the tactical edge. It enables high-performance, power-efficient data analytics and cognitive processing near sensors (e.g., video camera). To this end, this research proposes a reconfigurable deep learning processor to perform real-time deep learning inference with a fraction of a Watt. The key insight to increase efficiency is to minimize data movements at any architecture hierarchy level, exploit parallelism (spatial and temporal) across deep learning functional blocks, and remove the overhead of instruction-level programmability while maintaining enough flexibility. At the same time, this research proposes a Transparent Extensible Deep Learning Framework as a multi-layer software abstraction between the deep learning programming development and real-time execution on edge across heterogeneous devices. The aim is to enable both algorithm-dependent and architecture-dependent optimization to realize full AI and data analytics on the edge devices. Overall, this research opens a path to perform real-time complex stream processing near the sensors offering human-like and beyond human cyber cognitive abilities

New Faculty in 2017

Dr. Mihail Cutitaru
Teaching Assistant Professor
Ph.D., Old Dominion University, 2014

<u>Research Interests:</u> Embedded Systems, Digital systems modeling, Computer architecture, experimental learning.

Dr. Fareena Saqib
Assistant Professor
Ph.D., University of New Mexico, 2014

<u>Research Interests:</u> IoT security, hardware security and trust, supply chain risk management and security, physically unclonable functions (PUF) based authentication, high performance computing and hardware accelerator design using FPGAs.

Dr. Michael Mazzola
Duke Energy Distinguished Professor and EPIC Director
Ph.D., Old Dominion University, 1990
<u>Research Interests:</u> Power electronics, semiconductor devices, high-voltage engineering, power systems modeling, control of hybrid electric vehicle power trains.