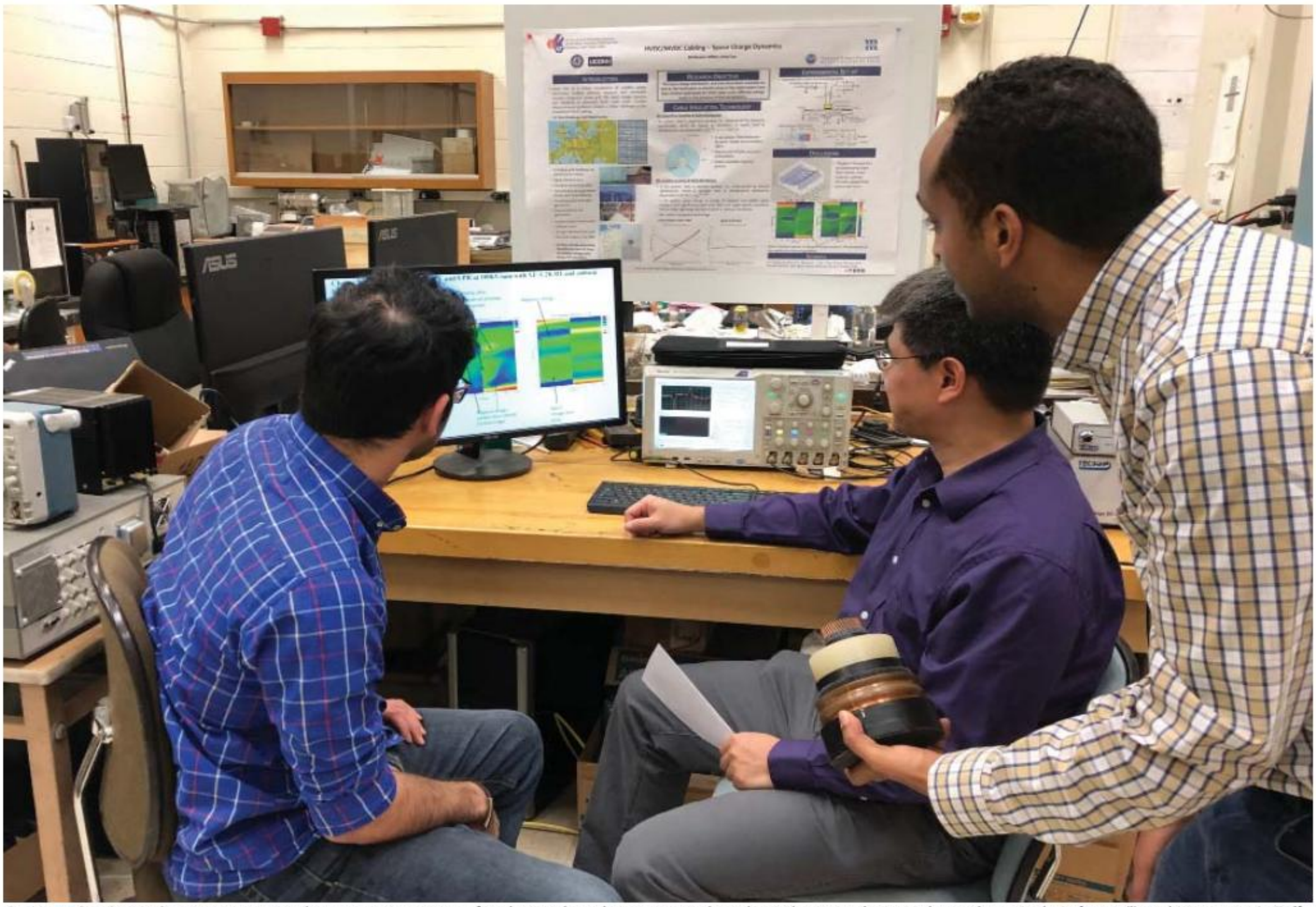
Innovators Bridge Divide Between Today's Applied Challenges and the Academic Frontier

by Kayla M. Pittman - Institute of Materials Science



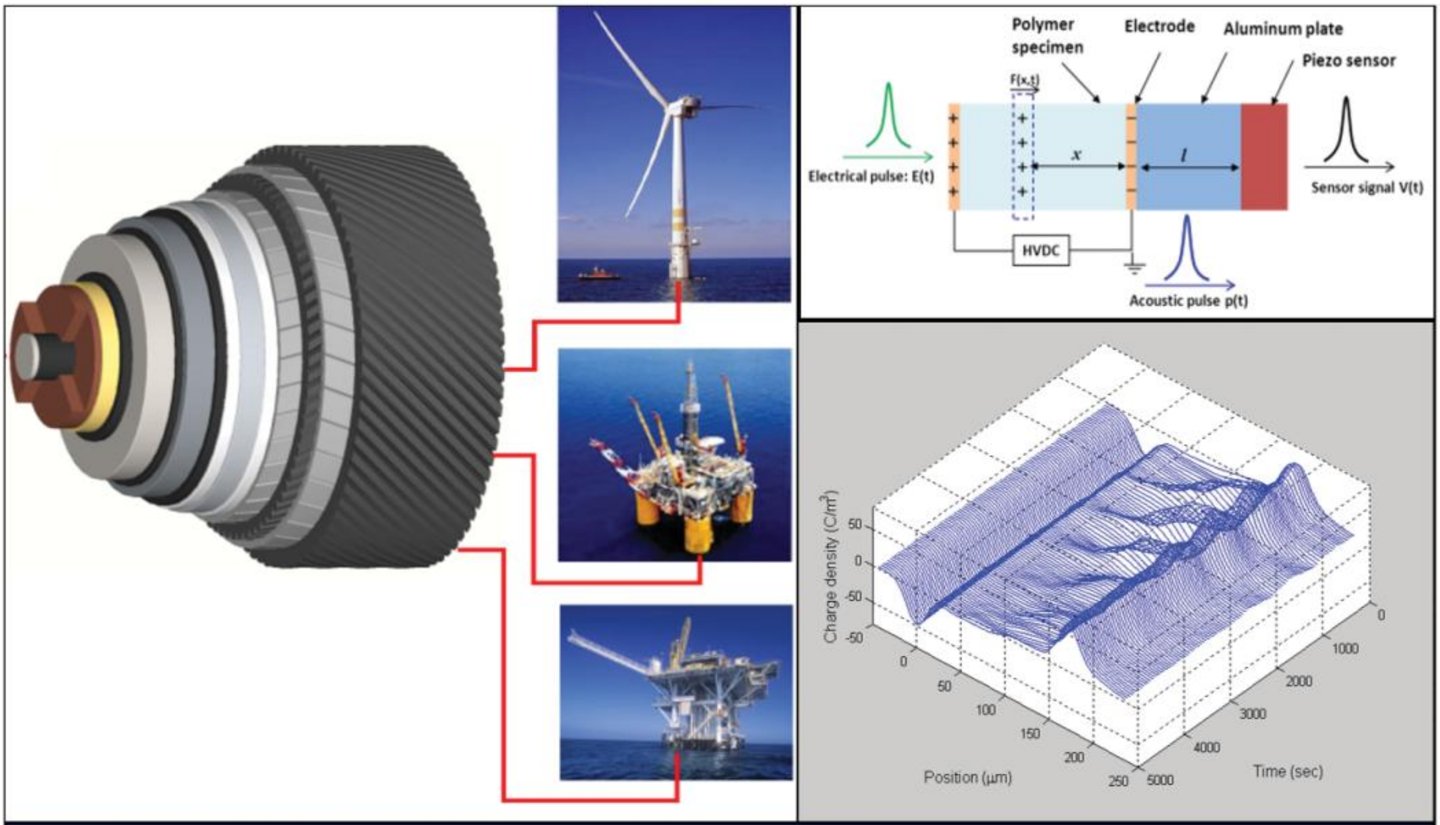
Dr. Yang Cao (center) reviewing space change measurements for electrical insulation materials with graduate students Mohamadreza Arab-Baferani (l) and Mattewos B. Tefferi.

Earning his doctoral degree in Materials Science from UConn before working in industry for eleven years, Dr. Yang Cao is no stranger to tackling practical problems with academic research. His work bridges the divide oftentimes found between academia and industry. Dr. Cao explains that both sides have their advantages in that academic research is exploratory as it drills down into the basic touchstones of a discipline, whereas industry is mission-driven with a sense of urgency to attain the end goal.

Succeeding his mentor, the late Dr. Steven Boggs, Dr. Cao now serves as the third Director of the Electrical Insulation Research Center (EIRC) in the Institute of Materials Science (IMS). The EIRC is an academic-based collaborative research center that, over the last thirty years, has developed materials and technical solutions to practical problems. Dr. Cao explains, "The EIRC is lucky in that it is centered between academia and industry, which affords this collaborative research center the opportunity to apply advanced scientific theories to practical problems." He goes on to say, "Knowing the academic principles presented in a problem does not mean you can fix it – the practical application of theory is not easy."

Dr. Cao's success in his role as Director is evidenced by not only the EIRC's collaborators from within IMS, but also global partners and funding stemming from government and industry sources. Despite his success, Dr. Cao remains humble and is quick to point out that long-time EIRC research assistant and lab manager, Ms. JoAnne Ronzello, is a constant in the lab. Fulfilling many roles, Ronzello propels the EIRC forward as the driving-force behind daily operations.

Currently, the EIRC is working on new dielectric materials and high voltage technologies to increase power density and enable high efficiency, as the world embraces renewables and broader ranges of electrification. A variety of ongoing projects include sponsorship from the United States (U.S.) Department of Defense (DoD) for a project focused on high energy density capacitors, the U.S. Navy for the development of marine electric propulsion motor insulation, and the U.S. Department of Energy



Energy efficient high voltage transmission technology for renewable integration

(DoE) for a project on high voltage direct current (HVDC) cabling and accessories.

In concert with his work with the EIRC, Dr. Cao also serves as a co-director of the Center for Novel High Voltage/Temperature Materials and Structures. The Center seeks to increase both the efficiency and reliability of the power infrastructure by working with both UConn collaborators as well as university and industrial partners from across the country. This undertaking is an extension of the National Science Foundation Industrial University Cooperative Research Center on High Voltage/Temperature. There is great synergy between all of Dr. Cao's projects, all working toward increasing power density in electric machines and drive systems.

Success in electrification relies on the ability to increase the high power density of the motor and converter. In doing so, the engine is smaller to decrease weight with the same power, or it generates more power at the same size. Dr. Cao is particularly excited about the future of hybrid propulsion in the aerospace industry. The EIRC is working on a National Aeronautics and Space Administration funded project with United Technologies (as part of a U.S. response to the partnership between Airbus, Rolls-Royce, and Siemens) to develop a hybrid-electric engine for commercial airplanes. The goal is to develop HVDC power distribution system for aerospace compulsion.

Power density is also the focal point of Dr. Cao's projects with the U.S. Navy and DoD. Working on two separate projects, the EIRC confronts a unique challenge in developing technology that fits within the restrictive confines of a battleship. Increasing the power density of the electric engines not only realizes electric propulsion in the engine room as seen on the DDG 1000 ship, but also the mechanism for high voltage breakdown in the U.S. Navy railgun as supported by a Multidisciplinary University Research Initiative (MURI) through the DoD. The current MURI project seeks to develop new capacitor materials for the railgun. This project is within its second award period with each period receiving 7.5 million dollars over the course of five years.

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As opposed to explosive ordinances, the railgun's destructive energy relies on the speed of the projectile produced by an electromagnetic force. BAE Systems, a railgun manufacturer, states the railgun launches high velocity projectiles at the speed of Mach 7.5; upon impact, the projectile is traveling at Mach 5. Again, the lack of space on battleships drives the need for high power density, which allows for the mechanism of the projectile's propulsion as well as the ability to store an increased

EIRC Lab Manager, JoAnne Ronzello

amount of smaller, non-explosive projectiles with the same or even greater impact.

The EIRC is also applying high power density electric engines to renewable energy applications such as wind power. Dr. Cao's research currently focuses on making improvements to turbine gearboxes for use in offshore wind power. According the U.S. DoE, offshore turbines are similar to land-based turbines in that to generate power, the blades harness the wind's natural kinetic energy and rotate. The resulting mechanical energy rotates an internal shaft connected to the gearbox. The gearbox is responsible for increasing the overall rotation speed by 100, spinning the generator fast enough to produce harvestable energy. However, offshore wind power generates significantly more energy. The Wind Solar Alliance reports that an average land turbine generates approximately two megawatts, or enough energy to power 750 average American homes. Offshore turbines generate approximately 9.5 megawatts. Locally, this is an exciting time to be working on wind power, as the Connecticut Department of Energy and Environmental Protection recently announced a 200-megawatt offshore wind purchase. With this technology on the rise, the EIRC is also developing safer, more efficient means of harvesting energy generated by offshore wind turbines.

In order to harness the high voltage direct current (DC) generated on large offshore wind farms, cables must carry the power from the turbines back to the grid. DC is characterized by electrons flowing constantly in one direction; whereas, alternating current (AC) moves in both positive and negative directions. Less stable than AC, working with DC at this scale presents a large challenge; when disconnected abruptly, it arcs causing a massive fire. Dr. Cao and the EIRC team are developing technology in line with Smart Grid, the digital modernization of the traditional electric grid originally established in the 1890s, allowing for greater power flow control.

With multiple projects both underway and on the horizon, Dr. Cao centers the EIRC on the edge of groundbreaking technological and materials advancements. When asked his goals for the future of the EIRC, Dr. Cao remains committed to fostering a sense of openness and collaboration between students and faculty, as well as industry and governmental partners. His measure of success: well-trained students and increased work.