L. Eric Cross of Pennsylvania State University remembered

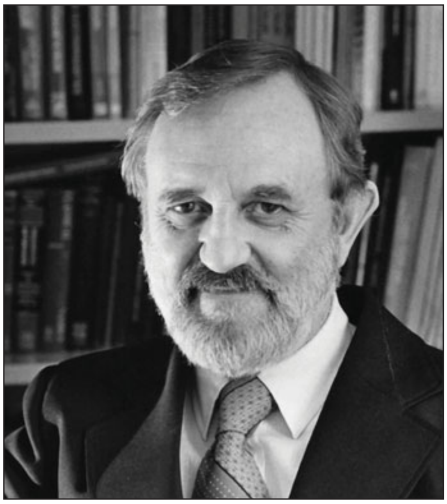
Professor L. Eric Cross passed away on December 29, 2016, at the age of 93. He was the Evan Pugh Professor Emeritus of Electrical Engineering at The Pennsylvania State University (Penn State), a member of the National Academy of Engineering, and a founding member of the Penn State Materials Research Laboratory. A world leader in the field of ferroelectrics, his contributions to the field encompassed fundamental aspects, new characterization techniques, and applications. Cross was beloved for his intelligence, vision, wit, and humanity, as well as the charm with which he shared his fascination with ferroelectrics and his newest ideas. He was an excellent mentor, and many of his students and postdoctoral researchers went on to scientific leadership positions.

Cross had a long and robust scientific career. His earliest published research was in characterization of the properties of $BaTiO_3$, including both optical response and switchable polarization. He made some of the first accurate measurements of spontaneous polarization in $BaTiO_3$, which were found to be substantially higher than previous data, by achieving more complete switching. It was not until his work was reproduced at Bell Labs that Cross's previously rejected paper on the subject was accepted by editors for publication with apologies. He later extended this work to $NaNbO_3$ and $K_xNa_{1-x}NbO_3$ (a material that is now under intense investigation as a lead-free piezoelectric material). This appears to have been his introduction to antiferroelectricity.

By the 1960s, he had arrived at Penn State, where he conducted seminal work on the use of phenomenology to describe the behavior of ferroelectric materials. He developed an early model for the grain size effect on the dielectric properties of $BaTiO_3$, initiated a long-running investigation of electrostriction, and studied improper ferroelectric materials such as gadolinium molybdate. In the 1970s and 1980s, in collaboration with longtime colleague and close friend Robert E. Newnham, he developed piezoelectric composites and laid out the symmetry requirements for secondary ferroics. The work on composites was originally motivated by his work on sonar systems, but ultimately led to major improvements in ultrasonic imaging transducers, and is now ubiquitous in medical ultrasound systems.

Cross conducted key measurements on the contributions of domain walls to dielectric and piezoelectric properties. He began an investigation into the origins of dielectric dispersion in ferroic materials. This ultimately led to major discoveries on the role of order-disorder in relaxor ferroelectric materials, as well as the Vogel–Fulcher description of the dispersion. He and his students also laid out the phenomenology of the lead zirconate titanate system—an essential means of describing the intrinsic properties of materials in the absence of single crystals. This work continues to be widely utilized and cited. His drive to ever-improved means of measuring strain and electromechanical coupling under a wide variety of temperatures, frequencies, and field conditions ultimately led to the development of numerous new measurement methodologies, including the use of a double-beam laser interferometer.

Cross's work with collaborators identified the origins of bridging phases near morphotropic phase boundaries in ferroelectric solid solutions, contributed to the understanding of domain engineered piezoelectric single crystals, designed new piezoelectric transducers and magnetoelectric composites, solidified our understanding of domain wall contributions to the nonlinear behavior of ferroelectrics, and was one of the first to exploit ferroelectric thin films for piezoelectrics in microelectromechanical systems. His final key contribution to the field was the discovery of anomalously large flexoelectric coefficients in perovskites, such as $Ba_{1-x}Sr_xTiO_3$.



(Top) Professor L. Eric Cross. (Bottom) Eric with his wife Cilla.

Cross contributed to the understanding of virtually every major ferroelectric material, as well as to their applications. He came to the field of ferroelectricity in its infancy, to the objection of his advisor E.C. Stoner, who referred to it as "… a trivial lattice phenomenon!" Many years later, Cross laughed that he was still occupied trying to understand this trivial phenomenon. He worked with companies all over the world on ferroelectrics for capacitors, piezoelectrics, pyroelectrics, dielectric bolometers, and electro-optic applications. He had a keen interest in practical solutions to problems. When the Hubble Space Telescope was found to have been launched with incorrectly ground mirrors, Cross worked closely with engineers to select the electrostrictive adjusters that restored the telescope to functionality. He also built his own oscilloscopes, as needed, to make measurements.

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Cross was very proud of his long association with the US Department of Defense and particularly the US Navy, which supported much of his work in the field of sonar undersea transducers. Through his lifelong friendship with Newnham, Cross helped to build a culture of cooperation and collegiality that aided in establishing the Materials Research Laboratory as a preeminent, interdisciplinary research facility.

During his career, Cross was named a Fellow of the Materials Research Society, the American Physical Society, the Optical Society of America, The American Ceramic Society, and IEEE. In 1983, he was elected to the National Academy of Engineering for his contributions to the development of electroceramic, dielectric, and piezoelectric materials. He was also the 2010 recipient of the Von Hippel Award of the Materials Research Society, its highest honor. Cross joined Penn State as a senior research associate in 1961, rose through the ranks, and in 1985, was named the Evan Pugh Professor of Electrical Engineering. An Evan Pugh Professorship is the highest distinction that the university can bestow on a faculty member. He was the author or co-author of more than 850 refereed papers, held 20 patents, and published a comprehensive textbook, *Domains in Ferroic Crystals and Thin Films*. At Penn State, he mentored >50 graduate students from across the world.

Cross shared his ideas and his time freely with everyone that he met, from graduate students to senior leaders in the field. He and his family opened their home to generations of students and colleagues. We will miss his trademark exclamation of "Jolly Good!", his spark of mischievous humor, and his tendency to wear socks and sandals with suits.

A set of memories embodying the scholar, the passion, and the personality of Prof. Cross can be found at http://ethw.org/Oral-History:L._Eric_Cross.

Clive A. Randall and
Susan Trolier-McKinstry
The Pennsylvania State University

DeSimone to present Kavli lecture during 2017 MRS Spring Meeting plenary session

Joseph M. DeSimone has been selected to present The Fred Kavli Distinguished Lectureship in Materials Science during the 2017 Materials Research Society (MRS) Spring Meeting to be held April 17–21 in Phoenix, Ariz. He is the Chancellor's Eminent Professor of Chemistry at The University of North Carolina (UNC) at Chapel Hill, and William R. Kenan, Jr. Distinguished Professor of Chemical Engineering at North Carolina State University, and of Chemistry at UNC. DeSimone is the CEO/co-founder of Carbon, Inc. in Silicon Valley.

DeSimone's presentation is titled "Future Fabricated with Light: Continuous Liquid Interface Production to Drive Additive Manufacturing." Despite the increasing popularity of 3D printing, also known as additive manufacturing (AM), it has not developed beyond the realm of rapid prototyping. This confinement of the field can be attributed to the inherent flaws of layer-by-layer printing and, in particular, anisotropic mechanical properties that depend on print direction, visible by the stair-casing surface finish effect.

This lecture will describe a new advance in AM that is rapid, continuous, and no longer layer-by-layer that promises to advance industry beyond basic prototyping to 3D manufacturing. Continuous Liquid Interface Production (CLIP) technology harnesses light and oxygen to continuously grow objects from a pool of resin instead of printing them layer by layer. CLIP capitalizes on the fundamental principle of oxygen-inhibited photopolymerization to generate a continual liquid interface of uncured resin between the growing part and the exposure window. This interface eliminates the necessity of an iterative layer-by-layer process, allowing for continuous production.

Continuous production has several advantages, including the fabrication of large overhangs without the use of supports, reduction of the stair-casing effect without compromising print time, and isotropic mechanical properties. Combined, these advantages result in multiple indicators of layerless and monolithic fabrication using CLIP technology.

DeSimone is one of less than 20 individuals who have been elected to all three branches of the US National Academies: National Academy of Medicine (2014), National Academy of Sciences (2012), and the National Academy of Engineering (2005). He is also a member of the American Academy of Arts & Sciences (2005). DeSimone has received more than 50 major awards and recognitions, including the inaugural Kabiller Prize in Nanoscience and Nanomedicine; the 2015 Dickson Prize from Carnegie Mellon University; the 2014 Industrial Research Institute Medal; and the 2014 Kathryn C. Hach Award for Entrepreneurial Success.

DeSimone is the co-founder of several companies, including Micell Technologies, Bioabsorbable Vascular Solutions, Liquidia Technologies, and Carbon. He received his BS degree in chemistry in 1986 from Ursinus College in Collegeville, Pa., and his PhD degree in chemistry in 1990 from Virginia Tech. DeSimone has published more than 300 scientific articles and has more than 150 issued patents. In June 2016, DeSimone was recognized by former US President Barack Obama with the National Medal of Technology and Innovation. □

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