

## Physics of Ferroelectric and Multiferroic Domains, Faceting and Actuation

The dynamics of ferroelectric and multiferroic nanodomains have been probed under the constant irradiation of energetic electron beams and conventional contact mode piezoforce microscopy. The oscillation, faceting, and movement of nano-ferroelectric domains, domain walls, and periodicity of freestanding  $\text{Pb}(\text{Zr}_{0.52}\text{Ti}_{0.48})\text{O}_3$  (PZT) nanocrystals and nanorods, and room temperature multiferroic  $\text{PZT-Pb}(\text{Zr}_{0.5}\text{Ti}_{0.5})\text{O}_3$  will be discussed. The behavior of multiferroic domains under E-fields and M-fields will be presented in the context of change in domains probed by weak energy PFM technology. The faceting of PZT nanocrystals from circular disk geometry to a sharply hexagonal shape has been observed by high-resolution transmission electron microscopy (HRTEM). Triangular-shaped domains don't show any oscillation or faceting. The behavior is analogous to that of spin structure and magnetic domain wall velocity oscillations in permalloy, involving overshoot and de-pinning from defects. A nondestructive E-beam with 300 kV energy was used to understand the actuation behavior of ferroelectric PZT/PVDF composite nanorods 1-5 microns in length and 50-200 nm in diameter under irradiation. It has been observed that nanorods move away almost 5 to 50 nm from the original position depending on the position and time of irradiation and probing/imaging. This mechanical deviation is reversible and robust in nature which indicates that it may be useful for future NEMS devices. Simulation and physical models of these nanostructures will be presented.



### ABOUT THE SPEAKER

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Ashok Kumar is a senior scientist at CSIR-National Physical Laboratory, New Delhi, India. He received a gold medal in his bachelor's and master's degrees, and obtained his doctorate in physics from T. M. Bhagalpur University/ IIT Kharagpur, India. He worked as a postdoctoral fellow in the department of metals and materials engineering at IIT Kharagpur to develop solid oxide fuel-cell technologies. From 2006 to 2012, he was on the research faculty in the department of physics at the University of Puerto Rico, and served as a visiting scientist in the department of materials science at the University of Cambridge in 2010. Kumar was also an assistant professor of pure and applied physics at Central University, Bilaspur, India. His area of specialization is fabrication and characterization of nanostructured ferroelectrics, nanoelectronics, superlattices, spintronics, relaxors, multiferroics, high-k dielectrics, high energy density capacitors, and ferroelectric tunnel junctions. He is actively involved in development of non-volatile random access memory elements and devices, magnetic field sensors, high power delivery systems, and photovoltaic devices for green energy. He has published more than 180 research papers in high-impact journals.

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