NANOSCIENCE COLLOQUIUM

Giant negative electrostriction effect in ferroelectric polymer nanostructures

By Mehmet BAYINDIR
Center for Hybrid Nanostructures, University of Hamburg

Abstract: Ferroelectric polymer PVDF, poly(vinylidene fluoride), and its copolymer P(VDF-TrFE), poly(vinylidene fluoride-trifluoroethylene), have elicited significant interest in recent years because of the ambiguity in understanding of the origin of the negative piezoelectricity and the giant negative electrostriction effect, and their potentials to innovate the actuator, sensor, transducer, and energy storage applications. However relatively low intrinsic piezoelectricity, electrostriction, and dielectric constants of the organic ferroelectric polymers hinders the wide spread applications of them in spite of their extraordinary properties including flexibility, stretchability, reliability (mechanical toughness), low cost, easy processing into intricate shapes, and biocompatibility. In past decades, unprecedented efforts have been made to improve the electromechanical properties of the ferroelectric polymers to revolutionize flexible electronics.
Recently we introduce a new relaxor polymeric system with a record-high negative electrostriction coefficient, Q33=-180 m4/C2, by transforming a nonpolar P(VDF-TrFE) macroscopic slab with rich VDF content, 75 mole%, into meters-long multilayered nanostructures. Forced two-dimensional confinement of P(VDF-TrFE) copolymer into hard-walled amorphous polyethersulfone nanotubes during thermal drawing affects the crystallization kinetics and growth dynamics drastically, and results in aligned polar nanoscale crystallites, ~50 nm, with relaxor properties. Nanofibers with an extraordinarily high electrostrictive strain, 7%, lead to ultra-sensitive large-area impact sensory modules used in cardiac arterial pulse measurements, artificial hand, electronic skin, and mechanical energy harvesting with single electrode configuration analogous to biological tactile sensory system.
The precise control of growth, crystallization kinetics, induced strain, and orientation of crystallites of polymers in confined nanostructures may be a new route to transform the ferroelectric polymers into the relaxor phase with outstanding properties, which are required for the emergence of the pervasive flexible electronics. Moreover obtaining high-quality crystals, high-crystallinity, and high-degree of alignment of the crystallites may reduce the structural and conformational complexity of electroactive polymers and might open up new avenues leading to better understanding of the fundamental properties of ferroelectric polymers.

Universität Hamburg
DER FORSCHUNG | DER LEHRE | DER BILDUNG

05.04.2022
1:15 pm | R 301 / CHyN

CHyN
Center for Hybrid Nanostructures