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PROCEEDINGS

Flexoelectric Polar Patterns in Wrinkled Thin Films

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ABSTRACT

Flexoelectricity is the coupling effect of polarization and strain gradients, which tends to be more pronounced in thin films owing to size dependency. When subjected to in-plane compression, a film-substrate system will form complex wrinkle morphologies along with large-area and tunable strain gradients. The wrinkle-induced strain gradients can locally break the inversion symmetry of dielectrics and thus introduce flexoelectric polarization. Here, an electromechanical coupling model is developed to theoretically deal with flexoelectric polar patterns in wrinkled thin films. By analyzing the energy competition of elastic potential and electrostatic energy, the amplitude, wavelength, and critical strain of the wrinkles with flexoelectricity in mind are redefined and the interplay between wrinkles and flexoelectricity is studied as well. Numerical and theoretical analyses reveal that wrinkling can trigger in-plane and out-of-plane dipole rotations, endowing the dielectric films with various polar structures, such as polar stripes and meron- or anti-meron-like nanodomains. It is also demonstrated that the wrinkle-induced flexoelectric polar patterns can be manipulated by compressive strains, offering a voltage-free method for mechanically modifying the intrinsic polarity of materials and enabling the conversion of nonpolar materials into polar or "piezoelectric-like" materials. Moreover, the results obtained in the current work also show that the available energy and stretchability of the wrinkled thin films can be improved by enhanced flexoelectricity in thinner films. These findings pave the way for wrinkle-based microelectromechanical devices and applications.

KEYWORDS

Flexoelectricity; polar patterns; wrinkle; electromechanical coupling

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