Mechanical Reading Of Ferroelectric Polarization

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The mechanical properties of materials are described by even parity tensors, therefore are believed to be insensitive to space inversion, even for non-centrosymmetric materials, such as ferroelectrics, i.e for a ferroelectric material the mechanical response should not depend on whether its polarization is pointing up or down.

This situation can change, however, if flexoelectricity is taken into account, because deforming a ferroelectric material in an inhomogeneous way will yield two sources of polarization: the piezoelectric one due to strain, and the flexoelectric one due strain gradients. These two polarizations can be parallel or antiparallel depending on the ferroelectric polarity, which in turn will result in two different electrostatic energy costs of the deformation.

Our recent work, using the nanoindentation technique and PFM images, provides experimental evidence that the mechanical response of a ferroelectric to inhomogeneous deformations depends on its polarity, and therefore it is switchable. This represents, on a fundamental level, a paradigm shift for the solid stated mechanics, and opens up the possibility of exciting and hitherto symmetry – forbidden physical effects. On a more practical level, the results also signify that flexoelectricity can be used not only to mechanically "write" ferroelectric bits, but also to "read" their polarity, thus conceptually enabling a purely mechanical (and thus voltage-free) operation of a ferroelectric memory.