Probing local switching currents induced by polarization reversal in an organic ferroelectric thin film

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Abstract:

Ferroelectric devices offer multiple advantages over other materials devices implementations, from low-energy information encoding to neuromorphic computing architectures [1, 2, 3, 4]. However, a precise understanding of how the polarization reversal occurs remains lacking. As electronic devices are shrunk to the nanoscale, their properties become more and more sensitive to defects, and to the physical properties that emerge at the interface, where different materials interact.

We demonstrate the successful detection of tiny ferroelectric switching currents of a few pico-amperes of magnitude originating from a nanoscopic region consisting of only a few grains in an organic ferroelectric thin film without any top electrode. By detecting the strain response of the region when submitted to the applied bias, we prove that the detected currents are indeed due to the polarization reversal occurring in the grains. The measurement of switching currents allows us to estimate the polarization charge density in a nanoscopic region (~300x300 nm2). As the ferroelectric system, we chose polycrystalline films of Croconic Acid (CA) [5, 6, 7] grown on Cobalt substrate in ultra-high vacuum environment, and performed in-situ spectroscopic measurements with a metallic tip in contact with the top surface. From these experiments, we report a nanoscopic polarization charge density of ~10 µC/cm2 which is of the order of the reported values of CA crystals [8]. For the sake of generality, we also extended the approach to a commonly studied inorganic ferroelectric material, $BiFeO_3$.

We are working towards switching current detection from even smaller areas; from a single grain or part of a grain in a polycrystalline film. The possibility to measure switching currents originating from the polarization reversal of single ferroelectric grains will pave the way towards understanding the fundamental ferroelectric properties at the granular level in continuous thin films. An understanding of the associated dynamics and of the kinetics of polarization reversal processes at granular level will lead to a better control over the switching processes in ferroelectric-based nanoelectronic devices.

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