In situ switching of ferroelectric nanodomains probed by X-ray nanodiffraction

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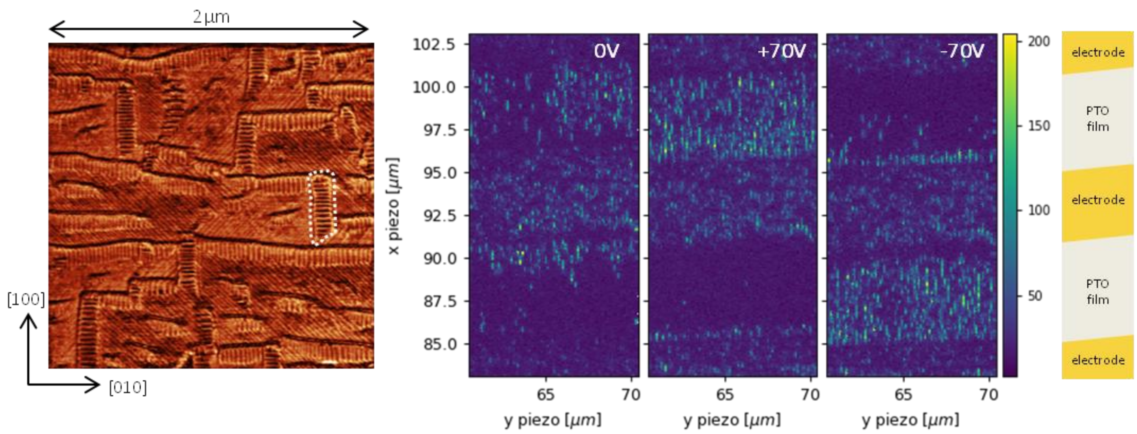
The promise of novel domain-wall based nanoelectronic devices has recently motivated much work concerning strain-engineered ferroelectrics with dense ferroelastic domain structures [1]. Certain thin film systems display an hierarchal organization, whereby ferroelastic domains arrange in distinct “superdomain” bundles [2]; the behavior of these superdomain structures under device- like conditions is still unclear.

Here we employ Scanning X-ray NanoDiffraction (SXND) [3] to investigate in-situ the response of an hierarchal ferroelectric thin film to in-plane applied electric field via a set of interdigitated electrodes deposited on its surface. We use PbTiO3 (PTO) // KTaO3 (KTO) thin films as a prototype system for this study due to the peculiar mixture of in-plane and out-of-plane domain bundles that PTO exhibits at the value of misfit strain resulting from deposition onto KTO substrates.

A typical piezoresponse microscopy image depicting the domain structure of a 62nm thick PTO//KTO thin film is shown on the left side of the figure below. In-plane a_1a_2 domain bundles are visible as diagonal stripes; out-of-plane *ac* bundles appear instead as horizontal and vertical “ladders” – an individual bundle is marked by a white dotted line. The right side of the Figure shows a SXND map (20x5um) displaying the distribution of *ac* domains as a function of applied voltage on the same PTO//KTO film. The map covers an area where both the interdigitated electrodes and the film’s surface in between those is visible, as the schematic on its right illustrates. The migration of one variant of *ac* bundles from one trench to the adjacent one due to the switching of the field lines direction under the inversion of the applied voltage polarity can be seen. Other kinds of bundles show different behavior which can also be visualized analogously, and based on these findings we propose to interpret this intricate domain structure and its response to in-plane electric field. We further demonstrate the value of SXND as a tool to investigate in-situ the structure of ferroelectric thin films to external stimuli.



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[2] Damodaran, A.R., et al. (2017) Journal of Physics: Condensed Matter, 28(26), p.263001
[3] Chahine, G. A., et al. (2014) J. Appl. Cryst. 47, 762–769