Domains in ferroelectric thin films: effect of epitaxial strain and electrodes

S. Matzen[1,2,*], A. S. Everhardt[2], O. Nesterov[2], B. Noheda[2], G. Catalan[3], G. Agnus[1], T. Maroutian[1], P. Lecoeur[1], M. Holt[4], E. Fohtung[5], O. G. Shpyrko[5], E. Fullerton[5]

[1] Institut d´Electronique Fondamentale, UMR CNRS, and Universite Paris-Sud, 91405 Orsay, France
[2] Zernike Institute for Advanced Materials, University of Groningen, 9747 AG Groningen, The Netherlands
[3] ICREA and CIN2, Campus Universitat Autonoma de Barcelona, Bellaterra 08193, Barcelona, Spain
[4] Advanced Photon Source, Argonne, Illinois 60439, USA
[5] Department of Physics, University of California-San Diego, La Jolla, California 92093-0317, USA
**contact: sylvia.matzen@u-psud.fr*

In ferroelectric epitaxial thin films, the presence of strain and strong depolarizing field can induce complex ferroelectric domain configurations, which necessarily affect the physical properties of the material (such as switching behavior, electrical transport, leakage currents…) and its coupling mechanisms to other functional layers, for example in magneto-electric hybrid heterostructures [1].

In this talk, I will present our recent results on the large degree of control of ferroelectric nanodomains in thin films, by tuning growth conditions, compositional variations and magnitude of epitaxial strain in different ferroelectric thin films.
Well defined out-of-equilibrium growth conditions allowed stabilizing some ferroelastic 90° domains (a/c twins), beyond the predictions of thermodynamical models, in $PbTiO_3$ films grown on $DyScO_3$ substrates [2], whose thickness dependence falls outside the validity range of the well-known square root law.
We used epitaxial strain in $Pb_xSr_{1-x}TiO_3$ ferroelectric thin films to control a complex domain architecture at two scales, with a purely in-plane polarization, which, despite the inherent difficulty to switch in-plane polarizations, allows the polarization to be easily manipulated by a scanning probe [3].
We have also investigated low-strain $BaTiO_3$ films on $NdScO_3$ substrate [4] and reported a low symmetry monoclinic phase (not present in single crystals) with a phase transition close to room temperature, providing a large polarization freedom in this material and promising perspectives for high piezoelectric response.

All these well-controlled and ordered ferroelectric structures can be exploited for tailoring physical properties and designing novel electronic devices based on thin films. However, their integration in functional devices requires an *in situ* local imaging of polarization morphology in real capacitor geometries, which remains challenging. I will present briefly the potential of the recently developed X-ray Bragg ptychography technique to enable nondestructive and high resolution imaging of polarization morphology in buried PZT thin films under realistic boundary conditions [5].

References

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