Structure, chemical analysis, and ferroelectric properties of chemical solution derived epitaxial $PbZr_{0.2}Ti_{0.8}O_3$ films for nanomechanical switching

I. C. Infante[a*], S. González-Casal[a], X. Bai[a], B. Vilquin[a], P. Rojo-Romeo[a], D. Albertini[a], N. Baboux[a], S. Brottet[a], B. Canut[a], J.-P. Barnes[b], M. Bugnet[c], B. Gautier[a]

a. Univ Lyon, INSA Lyon, CNRS, ECL, UCBL, CPE, INL, UMR 5270, 69621 Villeurbanne, France
b. CEA - Laboratoire d'Electronique et de Technologie de l'Information, 38054 Grenoble, France
c. Univ Lyon, CNRS, INSA Lyon, UCBL, MATEIS, UMR 5510, 69621 Villeurbanne, France

* email : ingrid.canero-infante@insa-lyon.fr

Ferroelectrics are a material class characterized by the presence of a spontaneous polarization, which can be switched under electrical and mechanical stimuli. Switching phenomena is a complex process entangled to electronic, chemistry and (micro)structural properties, and intrinsic and extrinsic defects, all these phenomena happening within the ferroelectric object and at its physical boundaries. Considering these phenomena becomes critical in the framework of ferroelectric nanostructures, *e.g.* integrated thin films, where interfaces and surfaces effects dominate against volume related properties.

Here we present the investigation of mechanical and electrical polarization switching on the prototypical tetragonal ferroelectric $PbZr_{0.2}Ti_{0.8}O_3$ (PZT) thin films. Using different routes for chemical solution derived processing and rapid thermal annealing crystallization of epitaxial PZT thin films, we gain control over the electrical properties, chemistry and microstructure of thin films of different thickness. The ferroelectric properties obtained from microcapacitors underline that polarization switching behaviors under electric field are compatible with out-of-plane *c*-oriented tetragonal PZT, depicting remnant polarization values close to bulk ones for film thickness above 100 nm. Interestingly, a decrease of measured remnant polarization and larger leakage current are observed in capacitors based on films with thickness below 100 nm as well as in those undergoing different crystallization processes. To understand the nanoscale nature of the ferroelectric properties of these films, we used atomic force microscopy (AFM) derived techniques, *i.e.* piezoresponse force microscopy and local piezoelectric hysteresis loops [1]. Through application of voltage and/or pressure using the AFM-tip, within different electrical boundary conditions, we studied the nucleation and switching phenomena in as grown and in electrically and pressure-induced patterned ferroelectric domains. Results on the coercive electric fields and threshold forces required for polarization switching of PZT films are analyzed in view not only of the different electrical and mechanical poling, but also on the microstructure, film density, defects and chemical composition determined from X-ray diffraction, scanning electron transmission microscopy and electron energy loss spectroscopy, Rutherford backscattering and secondary ion mass spectroscopies.

Polarization switching results of PZT films both at the micro- and nano-scales underline that the robust ferroelectric properties and switching mechanisms arise from reproducible chemistry, (micro)structure and defect distribution over thickness in chemical solution derived PZT films. These results will be discussed in the framework of integrated ferroelectric films for nanomechanical applications.

[1] S. González-Casal *et al.*, in preparation