Probing the Role of Surface Water In Ferroelectric Domain Charge Dynamics

I. Gaponenko[1*], N. Domingo[3], N. Stucki[2], A. Verdaguer[3], and P. Paruch[1]
[1]Department of Quantum Matter Physics, University of Geneva, Geneva, Switzerland
[2]University of Applied Sciences Western Switzerland in Geneva (HES-SO/hepia), Geneva, Switzerland
[3]Institut Català de Nanociència i Nanotecnologia (ICN2), Campus UAB, 08193, Bellaterra, Spain
*Iaroslav Gaponenko: iaroslav.gaponenko@unige.ch

Surface water is a ubiquitous presence on the surface of all materials exposed to ambient environmental conditions, inherently modifying the ground state in fundamental studies as well as affecting the operation of bare-chip devices. Specifically, by virtue of its polar nature, water strongly interacts with domains and domain walls in ferroelectric materials: it influences polarisation switching dynamics in $Pb(Zr_{0.2}Ti_{0.8})O_3$ thin films [1], and plays a key role (together with redistribution of oxygen vacancies) in the reversible control of electrical transport at 180° domain walls in this material [2].

Such water-polar surface interactions can be probed at the nanoscale by functional scanning probe microscopy. Here, we present our studies of the interaction of adsorbed water with written ferroelectric domains in thin films of $Pb(Zr_{0.2}Ti_{0.8})O_3$ by electrostatic force microscopy and Kelvin probe force microscopy imaging. The effect of polarization on the behaviour of the adsorbed water, as well as the influence of surface water on the underlying material, are investigated. Comparing domains written with both positive and negative tip voltage on films with opposite as-grown polarization states, we demonstrate the changes in the strength of the electrostatic interactions between the microscope tip and surface as a function of relative humidity and time. These are contrasted with ultrahigh vacuum measurements performed in "zero water" conditions, showing the importance of ambient conditions for domain engineering in ferroelectrics.

[1] C. Blaser and P. Paruch, New J. Phys. 17, 013002 (2015)
[2] I. Gaponenko, P. Tückmantel, J. Karthik, L.W. Martin and P. Paruch, Appl. Phys. Lett. 106, 162902 (2015)