Interface Dependent Domain Growth and Charge Transport Control in Lithium Niobate

S.M. Neumayer
School of Physics & Conway Institute, University College Dublin, Belfield, Dublin 4, Ireland
Sabine M. Neumayer: sabine.neumayer@ucd.ie

Controlling polarization switching and charge transport in ferroelectric materials is crucial for many applications ranging from ferroelectric memories and diodes to domain wall nanoelectronics, quasi phase matching optical devices and photodeposition of metal nanostructures. Electromechanical behavior and conductivity of ferroelectrics are apart from intrinsic material properties also strongly dependent on conditions at interfaces such as domain walls, internal boundaries of composite samples accompanied by a polarization gradient, screening charges at the surface as well as sample - electrode contacts. Understanding and exploiting these interfaces allows therefore to tailor the functional behavior of ferroelectric materials through sample design and experimental setup. In this work, the impact of conditions at internal and external interfaces on ferroelectric switching and charge transport was studied in LN using atomic force microscopy modes that allow to assess presence, size and evolution of domains as well as local conductivity and photoelectrochemical reactions. Internal boundaries between Mg doped LN (Mg:LN) and its proton exchanged (PE) phase inhibit stable polarization switching in Mg:LN, whereas in undoped LN, domain stability remains unaffected due to a difference in uncompensated charges and resulting depolarization fields.[1] Domain growth can be further controlled by initial sample polarization, relative ambient humidity and, especially in dry conditions, by sample thickness, providing a path for domain engineering in the submicron regime that might also extend to other single- and multilayer ferroelectric samples (Figure 1(a)).[2] Upon polarization switching, Mg:LN exhibited diode-like rectifying conductivity behavior, whereas at sub-coercive electric fields three conductivity states (on, off, intermittent), dependent on band bending at sample - electrode interfaces, were observed during UV illumination.[3] Introduction of domain walls that are accompanied by vertical and lateral electric fields across these boundaries, allowed to locally increase photocurrents (Figure 1(b)). The local change in charge transport behavior at domain walls can also be utilized in the fabrication of Ag nanostructures via photodeposition as reduction of Ag^{+} ions can preferentially occur at these interfaces.[4] Apart from ferroelectric domain patterning, introduction of PE phases in the crystal lattice allows for modification of the surface charge. In combination with using a specific type (Ag^{+} vs. Au^{3+}) and concentration of metal ions in the preparation solution, selective deposition of (alternating) arrays of Ag or Au nanoparticles can be achieved where the cytocompatibility of LN and Au might be used for Raman-based cell sensing.[5]

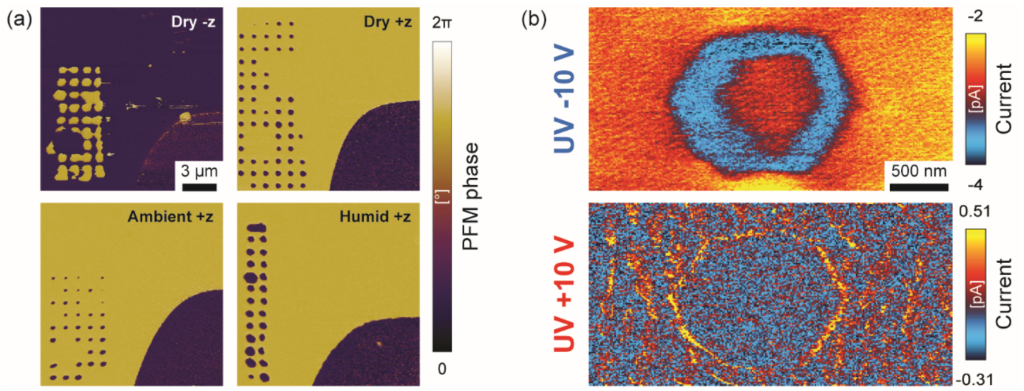

Figure 1. Interface modulated (a) domain growth and (b) photoconductivity in Mg:LN.

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