Imaging of charged ferroelectric domain walls for high density storage media

Downscaling of memory devices for ultra-high storage densities and low power consumption is a major challenge for post-CMOS electronics in order to implement new functionalities. Domain wall (DW) engineering in ferroic materials is one possible route where the DW rather than the bulk material becomes the active element. The challenge then is to predict and control the nanoscale DW functionality [1].

Charged domain walls (CDWs) in ferroelectric (FE) materials appear as a true, new paradigm for post-CMOS electronics precisely because they can be understood as nanometric mobile metallic conductors separated by highly insulating dielectric regions. They support currents nine orders of magnitude greater than in the intervening insulating domains [2]. However, their high electrostatic energy makes them instable and a specific preparation method is necessary.

Thin FE $BiFeO_3$ films will be epitaxially grown on substrates of suitable orientation in order to achieve the required strain state (collaboration with S. Fusil, UM Phys. CNRS/Thalès). CDWs stabilization is achieved by charge injection and in plane FE switching induced by a conducting tip in an atomic force microscope [2]. The so-called “trailing field” induced by the atomic force microscope tip motion allows selection of the suitable FE variant in neighboring domains, leading to the formation of a straight CDWs. Crystal growth under applied fields will be experimented for creation of CDWs arrays by frustrated poling.

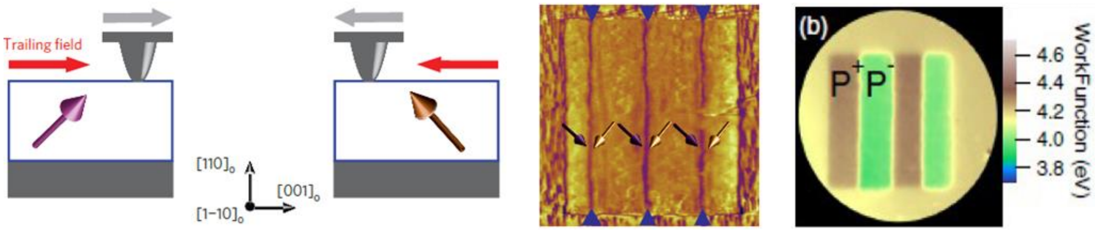

Figure: (left) polarization using the trailing field, (centre) 4x4 mm^2 area with head to head CDWs [2] and (right) PEEM characterization of domain and DW polarization [3]

The resulting CDW arrays will be studied using C-AFM, X-ray photoelectron spectroscopy (XPS) and photoelectron emission microscopy (PEEM) [3,4]

Techniques: The student will use PEEM to characterize the DW arrays [4]. Complementary analysis by AFM and XPS will also be carried out.
Qualities: The subject requires a good grounding in solid state physics and a desire for experimental teamwork.
PhD opportunities ? Yes. The Ecole doctorale Physique Île de France ou contrat CEA (CFR)

[1] G. Catalan, J. Seidel, R. Ramesh, Rev. Mod. Phys. 84, 119 (2012)

[2] A. Crassous et al., *Nat. Nanotech.* **10**, 614 (2015)

[3] J. Rault et al. *Phys. Rev. Lett.* **109**, 267601 (2012)

[4] N. Barrett et al., *J. Appl. Phys.* **113**, 187217 (2013)

Contact: Nick Barrett – Tel: +33 (0)1 69 08 32 72 – E-mail: nick.barrett@cea.fr

Website: http://iramis.cea.fr/spec/Phocea/Vie_des_labos/Ast/ast_visu.php?id_ast=2075