Domain and Domain Wall Imaging with Low Energy Electrons

N. Barrett[1], J.E. Rault[1], T.O. Mentes[2], A. Locatelli, G.F. Nataf, M. Guennou, J. Kreisel, P. Hicher, R. Haumont, L. Tortech, C. Mathieu, D. Martinotti
[1] SPEC, CEA, CNRS, Université Paris-Saclay, CEA Saclay, 91191 Gif-sur-Yvette Cedex, France
[2]Elettra-Sincrotrone Trieste S.C.p.A., Strada Statale 14 - km 163, 5 in AREA Science Park 34149 Basovizza, Trieste, Italy
[3]Materials Research and Technology Department, Luxembourg Institute of Science and Technology, 41 rue du Brill, 4422 Belvaux, Luxembourg
[4]ICMMO, UMR CNRS 8182, Bt 410 Université Paris Sud. 91405 Orsay Cedex, France
*Nick Barrett: nick.barrett@cea.fr

We use a low energy electron microscopy (LEEM) to image charged surfaces. At very low electron kinetic energy (KE), called mirror electron microscopy (MEM), electrons are reflected without penetrating the sample surface. At higher KE, the electrons penetrate the surface. In between, the reflectivity gives measure of the local work function or surface potential.

The transition from MEM to LEEM is therefore an ideal probe of surfaces showing polar or ferroelectric order [1]. Here we will show two examples of low energy electron imaging of charge ordering at surfaces.

We show how low energy electrons can reversibly switch and image in-plane polarized FE domains of a $BaTiO_3$ single crystal [2]. On electron injection the switching proceeds in a zig-zag around the direction [0-10]. It propagates as rather broad needles until reaching the opposite domain wall. Then, the needles expand until the polarization is switched in the entire domain. Low energy electrons switch the polarization without the collateral radiation damage which occurs with high energy electrons. Switching by charge injection adds a new dimension to the multifunctionality of ferroic oxides.

In a second example, we demonstrate that the polarization in domain walls of non-polar ferroelastic $CaTiO_3$ locally modifies the surface potential of the sample [3]. Domain walls with positive polarity can be screened by electron injection, reversible under annealing at 300C whereas the positions of the walls do not change. This is strong evidence of the polar nature of ferroelastic twins in $CaTiO_3$ resulting from biquadratic coupling between the antiferrodistortive tilts of the oxygen octahedral and the polarization. This may enable devices based on a non-destructive information readout of domain wall polarity.

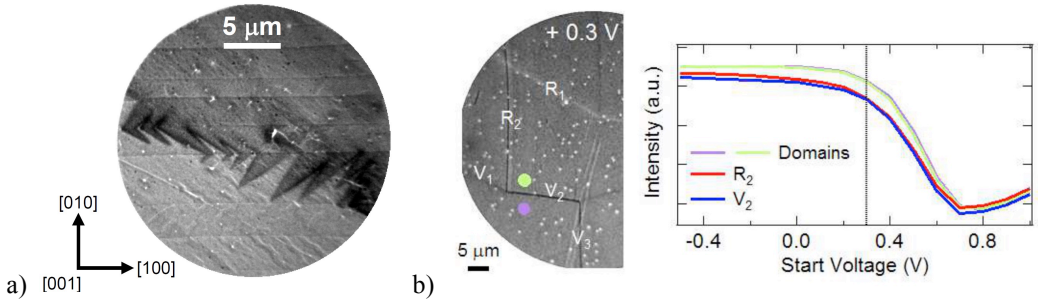

Figure a) MEM image of 180° switching of in plane domains in $BaTiO_3$(001) b) MEM image of positive and negative polarity ferroelastic domain walls in $CaTiO_3$(111). R and V stand for ridges and valleys.

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