PEEM imaging
of ferroelectric domain surfaces

Nick Barrett

Université Paris-Saclay, CEA, CNRS, SPEC, 91191,
Gif-sur-Yvette, France

nick.barrett@cea.fr

Ferroelectric materials have a spontaneous order parameter, the electric polarization, which is reversible under application of an external field. To minimize their free energy, they organize into domains of constant polarization, separated by domain walls. The symmetry related ground states makes them of prime interest for fast, low-power electronics. Photoemission electron microscopy is an ideal tool to probe local polarity, potential and chemistry of ferroelectric domains surfaces.

We present a PEEM study of the evolution of the $BaTiO_3$(001) surface through the ferroelectric-paraelectric phase transition. In- and out-of-plane polarized domains are observed. Adsorbate screening results in inversion of the electrostatic surface potential. Surprisingly, domain-related structure is still observed well above the transition temperature due to a combination of atomic relaxation and oxygen vacancies near domain walls whereas higher temperature allows a full reorganization of the domain configuration [1].
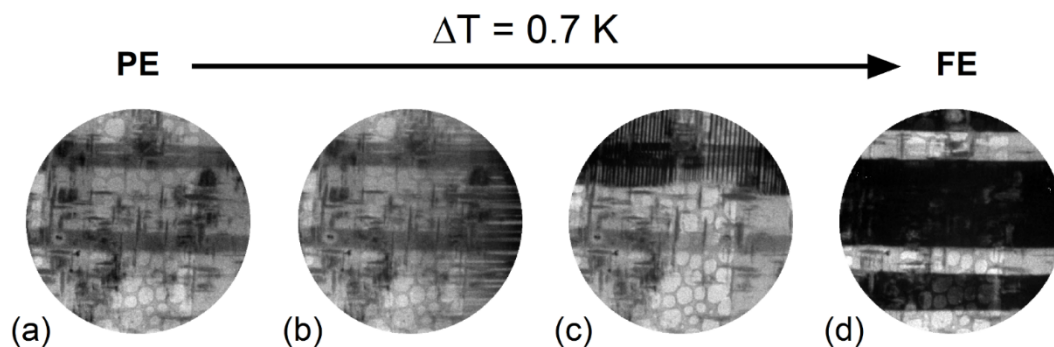

Figure Threshold PEEM images of the $BaTiO_3$(001) surface during the phase transition. Tweed-like structure and transitory elastic domains are visible. The field of view is 67 μm.

Despite the fact that domain formation minimizes the free energy, there is no reason why the initial ordering should corresponds to the equilibrium position. In fact, domain wall movement proceeds by jerks or avalanches, called creep. Creep dynamics are well known in metallurgy and seismology and are scale invariant. The probability of a jerk event of energy E is described by a power law [2].

We have used PEEM to follow two-dimensional creep at the $BaTiO_3$(001) surface during the phase transition. Domain wall movement exhibits a power law dependence with an energy exponent $\varepsilon \sim 1.33$, suggesting a wider range of possible jerk energies at the surface.

References

[1] C. Mathieu *et al. Sci Rep.* **8**, 13660 (2018)
[2] .K.H. Salje *et al. Phys. Rev. Mat.* **3**, 014415 (2019)