Disorder in the machine: the crucial role of defects in ferroelectric switching, and roughness and electrical conduction of domain walls

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Domain walls in (multi)ferroic materials are the thin elastic interfaces separating regions with different orientations of magnetisation, electric polarisation, or spontaneous strain. Understanding their behaviour, and controlling domain size and stability, is key for their integration into applications, while fundamentally, domain walls provide an excellent model system in which the rich physics of disordered elastic interfaces can be accesses. In addition, domain walls can present novel properties, quite different from those of their parent materials, making them potentially useful as active components in future nano-devices.

Here, we present our atomic force microscopy studies of ferroelectric domain walls in epitaxial Pb(Zr0.2Ti0.8)O3 and BiFeO3 thin films, in which we use piezorespose force microscopy to show unusual domain wall roughening behaviour, with very localised disorder regions in the sample leading to a complex, multi-affine scaling of the domain wall shape [1]. We also show the effects of temperature, environmental conditions, and defects on switching dynamics and domain wall roughness [2]. We combine these observations with parallel conductive-tip atomic force microscopy current measurements, which also show highly localised variations in conduction, and highlight the key role played by oxygen vacancies in the observed domain wall conduction [3].

[1] Guyonnet et al., PRL 109, 147601 (2012)

[2] Paruch et al, PRB 85, 214115 (2012); Blaser et al, APL. 101, 142906 (2012)

[3] Guyonnet et al., Adv. Mat. 25, 5377 (2011)