4.4 Deconvolution of Topographic and Ferroelectric Contrast in Scanning Force Microscopy

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Application of scanning force microscopy (SFM) for the inspection of ferroelectric sample surfaces allows the direct distinction between sample surface topography and ferroelectric features. While the former is determined by the physical shape of the sample surface and hence dominated by van der Waals forces, ferroelectric contribution stems from the occurrence of permanent polarization within the ferroelectric material. Such contributions are therefore described by long ranged electrostatic interactions and may be sensed even far away from the sample surface.

Ferroelectric domains are only vaguely seen in topographic SFM pictures performed in the contact mode of imaging. Further, the as-measured step heights significantly deviate from the value given by non-contact measurements, although the same cantilever was used for both imaging modes. This shows that contact and non-contact images are not simply view graphs of the topographic features, but also reflect the sub-surface contribution exerted by electric long-range forces. Nevertheless, domains become visible in the contact SFM mode when simultaneously recording the local friction exerted to the tip. Due to surface charges (either bound charges from the ferroelectric polarization or free charges found at the sample surface) the cantilever shows a different torsion when scanned over a ferroelectric domain with different polarity. This then shows up by a difference in brightness for differently polarized ferroelectric domains.

Both the non-contact and the friction force pictures demonstrate that the measured force contrast is always uniform over the whole area of the ferroelectric domain, at least of the size treated here. From theoretical calculations, we know that the electric field gradient should increase when coming close to the domain wall. However, no such effect is seen from our SFM images. This means that the electric field decays in a distance smaller than 4 nm from the domain wall. Another explanation could be that the bound charges at the sample surface are more effectively screened close to the domain boundary which again might result in a uniform force component perpendicular to the sample surface.