PFM – Can One Escape From the Artifacts All Around This Technique?

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Today, piezoresponse force microscopy (PFM) is the standard technique for imaging ferroelectric domain patterns. Indeed, this technique impresses by its tempting simplicity, and both, stunning sensitivity and remarkable resolution. Hence, basically every publication comprising a ferroelectric material is valorized with pleasing PFM-images. Their interpretation, however, is generally by far more sophisticated than gullibly assumed. As a consequence, the allegedly unambiguous interpretation of PFM images might not always stand a more questioning analysis. And this is what this tutorial will be about: to reveal the pitfalls of "plug & play-PFM" and discuss whether there is a way to - at least partly - circumvent them, and if not, whether one can - at the very least - identify them.
Subjects that will be addressed in this tutorial list as follows:

- Settings for PFM:
  how should one choose the scanning parameters of the AFM and the settings of the lock-in amplifier for optimum PFM-imaging?
- Quantitative PFM:
  is it possible to obtain quantitatively reliable values for piezoelectric coefficients?
- Local sample deformation in PFM:
  can one quantify (in 3D) the local deformation of the sample surface beneath the tip?
- Lateral resolution in PFM:
  what determines - apart from the tip radius - the lateral resolution of PFM-imaging?
- Electrostatic contribution in PFM:
  does the electrostatic interaction between the charged tip and the surface-polarization charging affects the PFM-signal?

In my tutorial, I will introduce some relevant basics of atomic force microscopy (AFM) and also discuss the inner workings of a lock-in amplifier, both as far as this is necessary for a better understanding of PFM. I will then present a series of experimental results demonstrating the troubles of PFM with the aim of inculcating a warier dealings with PFM-results. Note: I will only discuss standard-PFM, and therefore neither go into detail on more advanced PFM-methods nor present a deep theoretical background.

The motto of this tutorial could read: Be careful with PFM-results, may the PFM-images be ever so beautiful!