Simultaneous current-, force- and work function measurements

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In principle the local work function of a surface determines the spatial decay of the charge density at the Fermi level normal to the surface. First, a method is presented that enables simultaneous measurements of local work function and tip-sample forces [1]. A combined dynamic STM and AFM is used to measure the tunnelling current between an oscillating tip and the sample in real time as a function of the cantilever`s deflection as well as the frequency shift that results from the tip-sample forces. We used various qPlus sensors with a k of at least 1800 N/m for stable operation at small amplitudes. The high stiffness is required to comply with the stability criteria in frequency modulation (FM) AFM [2]. Amplitudes in the sub-Å range are required such that I remains above the noise level of the current amplifier even when the tip is at the far point of the surface. The presented method is a combination of ´current-imaging-tunnelling-spectroscopy´ introduced by Pethica et al. [3] and FM-AFM.
Figure 1 contains a simultaneous measurement of topography (constant average current), decay constant κ of the tunnelling current, frequency shift Δf and damping signal ΔE_C per oscillation cycle on a silicon (111)-(7x7) surface in UHV. Figure 1 shows that while all adatoms appear bright in the frequency shift image c), κ shown in b) displays a contrast inversion on the two halves of the Si unit cell. Currently, we adapt this technique to investigate the electronic states of oxide surfaces such as TiO_2.

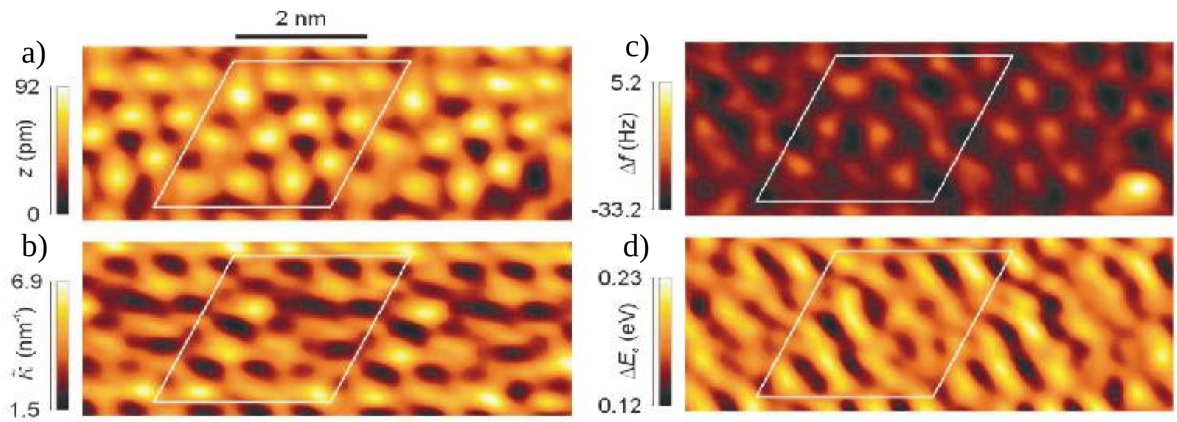

Fig.1 Simultaneous current-, force- and work function measurement with atomic resolution on silicon (111)-(7x7) with a tungsten tip and a qPlus sensor with a quality factor of Q = 2240; the surface cell is indicated with white diamonds;
a) topography; b) work function; c) frequency shift; d) damping

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[2] F.J. Giessibl, Rev. Mod. Phys. **75**, 949 (2003)
[3] J.B. Pethica, J. Knall, J.H. Wilson, Inst. Of Physics Conf. Ser., London **134**, 597 (1993)