NANONIS APPLICATION NOTE

MODULATION OF CONTACT RESONANCES: USE OF PLL IN *contact* MODE AFM

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Friction force microscopy (FFM) is a useful technique capable of characterizing material mechanical properties, such as elastic module, adhesion, and friction down to atomic scale. When combining static lateral force measurements with dynamic measurements of contact resonance frequencies the sensitivity is improved, i.e. subsurface defects are easier to detect than in conventional quasi static FFM.

We performed FFM measurements with our cantilever based RT UHV-AFM controlled by the Nanonis electronics. The digital integrated Nanonis OC4 (PLL) was used to track and actuate the first flexural resonance frequency (f_1) of an AFM cantilever in contact with the surface. Small excitation amplitudes (tens of pm) were used. Variations of the contact resonance frequency during the regular stick-slip motion of the cantilever over each atomic unit cell of the surface lattice are reliably detected. The normal contact frequency and the calculated normal contact stiffness show maximum values when the contact is not stressed in the lateral direction. Even more, enhanced sensitivity is proved by the resolved atomic-scale defects in the contact resonance frequency map. The variation of the resonance frequency in a particular unit cell is clearly distinct from its variation in the surrounding lattice sites, whereas the lateral force signal barely reveals specific features at this location, Figure 1.

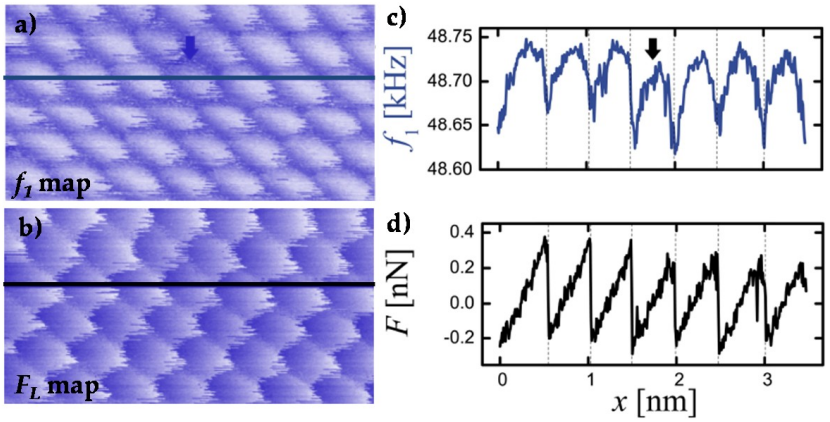

Figure 1. a) First flexural contact resonance map and (b) lateral force map measured simultaneously on NaCl(001). Scan line profiles: c) the contact resonance (blue) and d) the lateral force (black). The arrow indicates local defect, with no equivalent feature in the lateral force. F_N= 2.9 nN, normal oscillation amplitude is 50 pm.

Furthermore, atomic-scale contact resonance imaging seems to be promising for studying heterogeneous surfaces on the nanoscale, i.e. chemical identification and highly resolved spatial distribution of mechanical properties.

1] P. Steiner et al.,Nanotechnology 20, 495701 *(2009)*

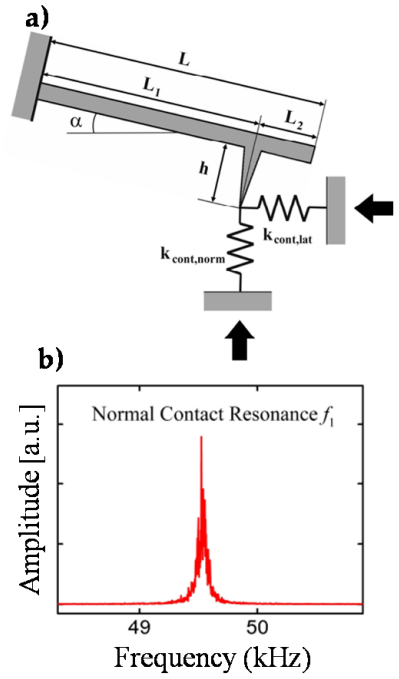

Figure 2. a) Proposed linear contact-resonance model for rectangular cantilever b) the flexural contact resonance frequency f_1 of the cantilever in contact with the NaCl(100) surface.

Nanonis Modules in Use:

- Base Package
- Oscillation controller OC4
- Dual OC4
- LabView Programming Interface

System:

- Home-built UHV RT- AFM

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