SPM 150 Aarhus with KolibriSensor™

Atomic resolution NC-AFM imaging with sub-angstrom oscillation amplitudes at room temperature

Application Notes

Atomic resolution imaging on insulating KBr(001) with oscillation amplitudes down to 0.3 Å

In non-contact atomic force microscopy (NC-AFM), the forces acting between an oscillating tip and the surface are measured. In principle a superposition of long- and short-range forces is always detected. To obtain atomic resolution it is essential to enhance the sensitivity for the short-range chemical forces. These forces have a typical decay length of about an angstrom and below. The detection of the short-range interaction can be significantly enhanced by applying small oscillation amplitudes of the same order of magnitude as the decay length of the short-range chemical interaction forces [1, 2, 3].

To operate with oscillation amplitudes in the sub-nanometer range, the AFM sensor has to meet two requirements. First, a high spring constant is required to avoid snap-into-contact [3]. The relatively soft spring constant of silicon cantilevers is the reason why in cantilever based AFM, an oscillation amplitude in the range of several nanometers is usually applied. Second, an excellent signal-to-noise ratio of the oscillation detection is required to ensure stable operation at small amplitudes.

The SPM 150 Aarhus with KolibriSensor™ meets both requirements enabling sensor operation at sub-angstrom oscillation amplitudes at room temperature. Benchmark atomic resolution measurements on insulating KBr(001) with oscillation amplitudes down to 0.3 Å at room temperature are presented. These results demonstrate the outstanding imaging performance and extraordinary stability of the KolibriSensor™.

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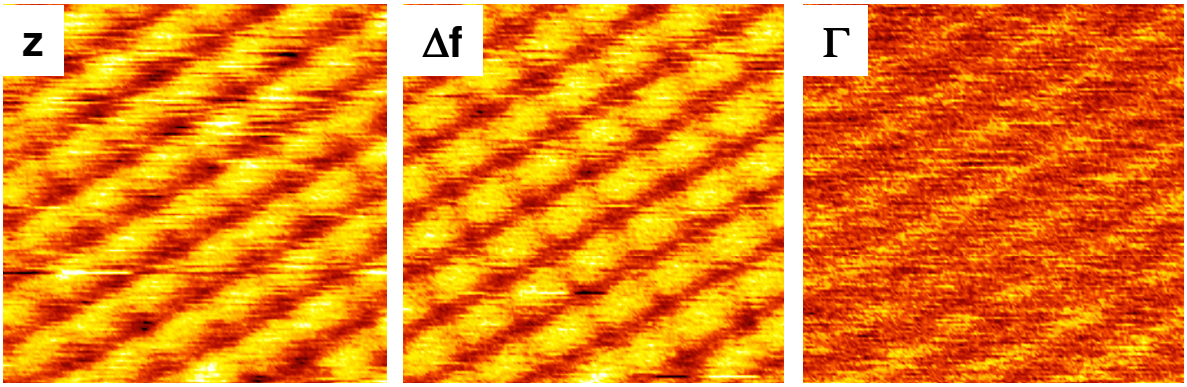
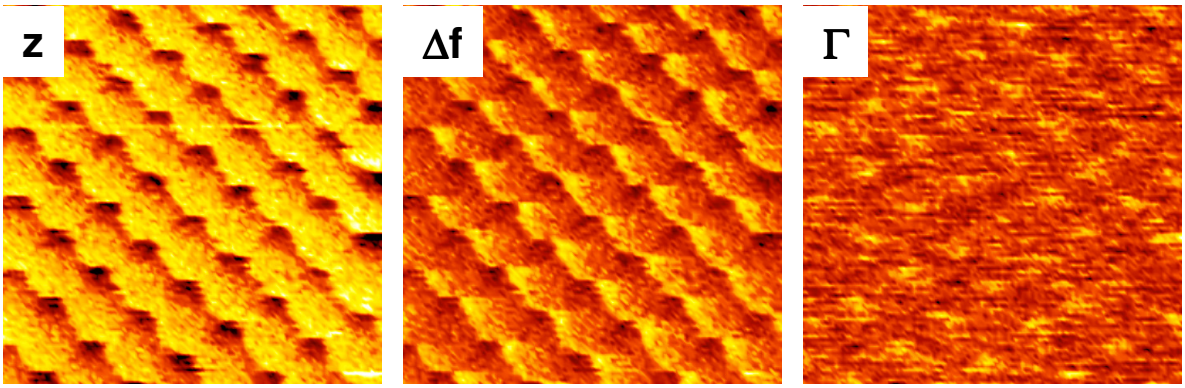
Oscillation Amplitude A = 1.0 Ångstrom



Oscillation Amplitude A = 0.5 Ångstrom



Oscillation Amplitude A = 0.3 Ångstrom

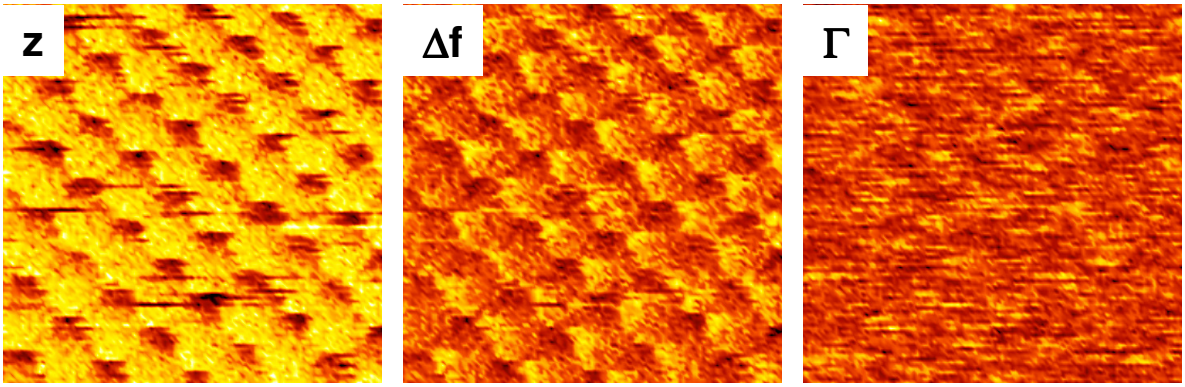


Figure 1: Atomic resolution topographic images on KBr(001) at various oscillation amplitudes at room temperature. Topography (z), detuning (Δf), and dissipation (Γ) signals are recorded simultaneously.

Image size (1.5 nm x 1.5 nm), f_{res} = 996,033 Hz, U_{CPD} = 2.03 V respectively.
A = 100 pm, Δf = +0.91 Hz, 2.0 lines/s, 128 x 128 pixels
A = 50 pm, Δf = +1.41 Hz, 2.5 lines/s, 128 x 128 pixels
A = 30 pm, Δf = +1.61 Hz, 2.5 lines/s, 128 x 128 pixels

All displayed data have been recorded with no external dampers for the UHV system at SPECS Laboratory.

Displayed images represent raw data with no filtering or smoothing applied.

References

[1] Calculation of the optimal imaging parameters for frequency modulation atomic force microscopy,
Giessibl, F. J., et al., Appl. Surf. Sci. **140**, 352 (1999)

[2] Physical interpretation of frequency-modulation atomic force microscopy
Giessibl, F. J., et al., Phys. Rev. B, **61** (15)**,** 9968 (2000)

[3] Dynamic force spectroscopy using cantilever higher flexural modes
Sugimoto, Y., et al., Appl. Phys. Lett., **91**, 093120 (2007)

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