SPM 150 Aarhus with KolibriSensor™

Atomic Resolution NC-AFM on Si(111)-(7x7)

**Application Notes**

- Highest Resolution, constant detuning NC-AFM imaging at room temperature
- Atomic corrugation up to 120 pm
- Stable imaging of adsorbates and vacancies on the surface
- Identification of faulted and unfaulted half in NC-AFM images
- Atomic resolution imaging of an atomic step
- Constant detuning imaging in the repulsive interaction region with atomic resolution

All of the following data was recorded with no external dampers on the UHV system at SPECS’ Laboratories.

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

Measurement: S. Torbrügge, SPECS GmbH
Figure 1: Constant detuning NC-AFM image.

Image size: 6 nm x 6 nm, \( f_{\text{res}} = 996,577 \) Hz, \( Q = 17500 \), \( \Delta f = -0.3 \) Hz, \( A = 200 \) pm, \( U_{\text{CPD}} = 0.070 \) V, imaging speed: 2.5 lines/s, (512 x 512) pixels
Figure 2: Constant detuning NC-AFM image.

Image size: 6 nm x 6 nm, $f_{res} = 996,577$ Hz, $Q = 17500$, $\Delta f = -0.5$ Hz, $A = 200$ pm, $U_{CPD} = 0.070$ V, imaging speed: 2.5 lines/s, (256 x 256) pixels
Figure 3: Constant detuning NC-AFM image.

Image size: 6 nm x 6 nm, $f_{res} = 996,577$ Hz, $Q= 17500$, $\Delta f = -0.3$ Hz, $A = 200$ pm,
$U_{CPD} = 0.070$ V, imaging speed: 20 lines/s, (512 x 512) pixels
Highest Resolution NC-AFM imaging on Si(111)-(7x7)

Figure 4: Height Profile Analysis

A typical corrugation of 120 pm is observed
Figure 5: Constant detuning image of defects on the Si(111)-(7x7) surface

Image size: 15 nm x 15 nm, $f_{\text{res}} = 996,577$ Hz, $Q = 17500$, $\Delta f = -0.45$ Hz, $A = 200$ pm, $U_{\text{CPD}} = 0.070$ V, imaging speed: 2.5 lines/s, (512 x 512) pixels
Figure 6: NC-AFM constant detuning (topography) imaging of defects on the surface.

NC-AFM imaging of clean and defective areas on Si(111)-(7x7)
Identification of faulted and unfaulted half on Si(111)-(7x7) in NC-AFM imaging

Figure 7: NC-AFM constant detuning (topography) image of the faulted and unfaulted half
Image size: 12 nm x 12 nm, \( f_{res} = 996,577 \) Hz, \( Q = 17500 \), \( \Delta f = -0.60 \) Hz, \( A = 200 \) pm, \( U_{CPD} = -0.19 \) V, imaging speed: 6.6 lines/s, (512 x 512) pixels

The faulted half is contrasted bright compared with the unfaulted half, and the corner hole adatoms are observed brighter than the center adatoms [1].

[1] Atomically resolved imaging by low-temperature frequency-modulation atomic force microscopy using a quartz length-extension resonator
Figure 8: NC-AFM constant detuning image of an atomic step

Image size: 20 nm x 20 nm, $f_{res} = 996,577$ Hz, $Q = 17500$, $\Delta f = -0.33$ Hz, $A = 200$ pm, $U_{CPD} = 0.070$ V, imaging speed: 2.0 lines/s, (512 x 512) pixels
Atomically resolved NC-AFM imaging in the attractive and repulsive regime on Si(111)-(7x7)

Figure 9: Jump of the tip from the attractive to the repulsive regime during NC-AFM constant detuning imaging

Image size: 15 nm x 15 nm, 
\( f_{\text{res}} = 996,577 \text{ Hz, } Q = 17500, \) 
\( \Delta f = -/+/0.35 \text{ Hz, } A = 200 \text{ pm, } \)
\( U_{\text{CPD}} = 0.070 \text{ V, } \)
imaging speed: 3.5 lines/s, 
(512 x 512) pixels
Figure 10: Consecutive recorded constant detuning images in the repulsive region

Image size: (20 x 20), (15 x 15), (12 x 12), (8 x 8) nm²,

\( f_{\text{res}} = 996,577 \) Hz, \( Q = 17500 \), \( \Delta f = +0.44 \) Hz, \( A = 200 \) pm,

\( U_{\text{CPD}} = 0.070 \) V, imaging speed: 3.5 lines/s, (512 x 512) pixels, respectively