Surface Analysis Technology | Vacuum Components | SPECS® | Surface Analysis System Software | Computer Technology

SPM 150 Aarhus with KolibriSensor®

On-the-Fly Switching Between STM and AFM Topography Feedback

Application Notes

The separately contacted metallic tip attached to the KolibriSensor® allows one to carry out combined STM (either with oscillating or static tip) and nc-AFM studies on conducting substrates. The Nanonis Controller features on-the-fly switching between both feedback modes which enables imaging of the same areas on the surface at atomic resolution. Especially for the identification of atomically sized defects, imaging in both feedback modes provides additional insights which are of fundamental importance as an intuitive interpretation of SPM images is often misleading.

The following pages provide data on:

- **Imaging of the same areas on Si(111)(7x7) and HOPG in STM and nc-AFM feedback mode**
- **Atomic resolution imaging of defects on the Si(111)(7x7) surface by oscillating STM and nc-AFM**
- **Discrimination of missing adatoms and adsorbates by an analysis of STM and nc-AFM images of the same area**

All data was recorded with no external dampeners on the UHV system at the SPECS Laboratory.

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

Measurement: S. Torbrügge, SPECS GmbH

KolibriSensor®

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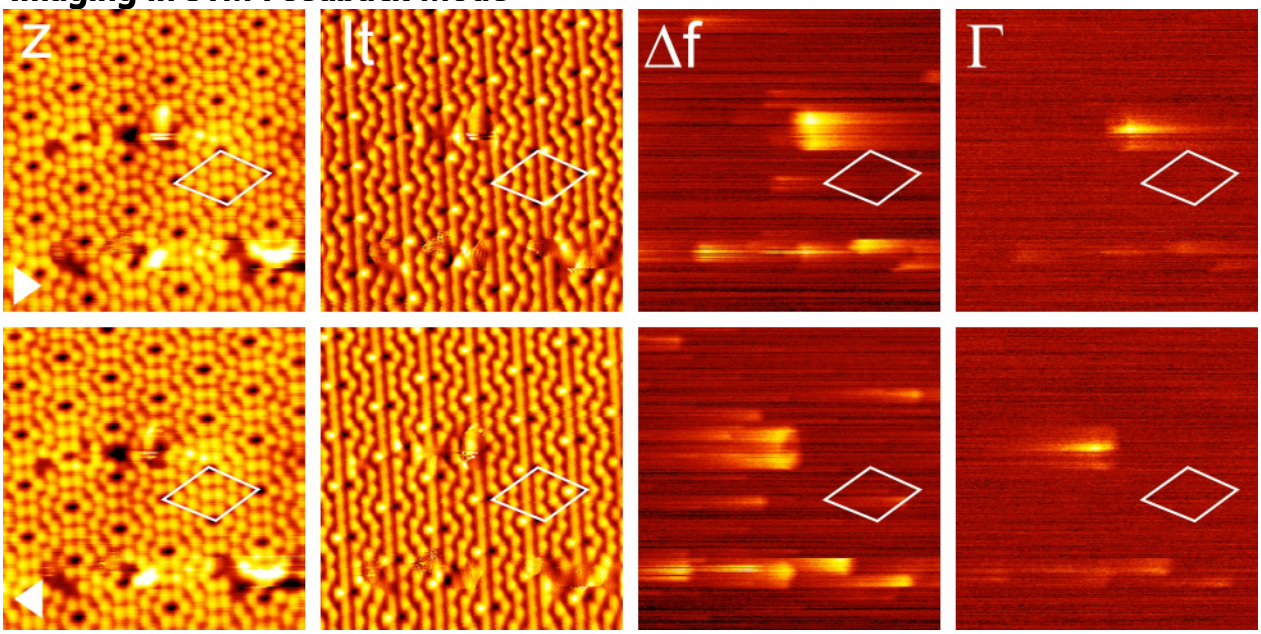
Successive Atomic Resolution Imaging of the Same Area in STM and AFM Feedback Mode on Si(111)-(7x7)

Imaging in STM Feedback Mode



Imaging of the Same Area in nc-AFM Feedback Mode

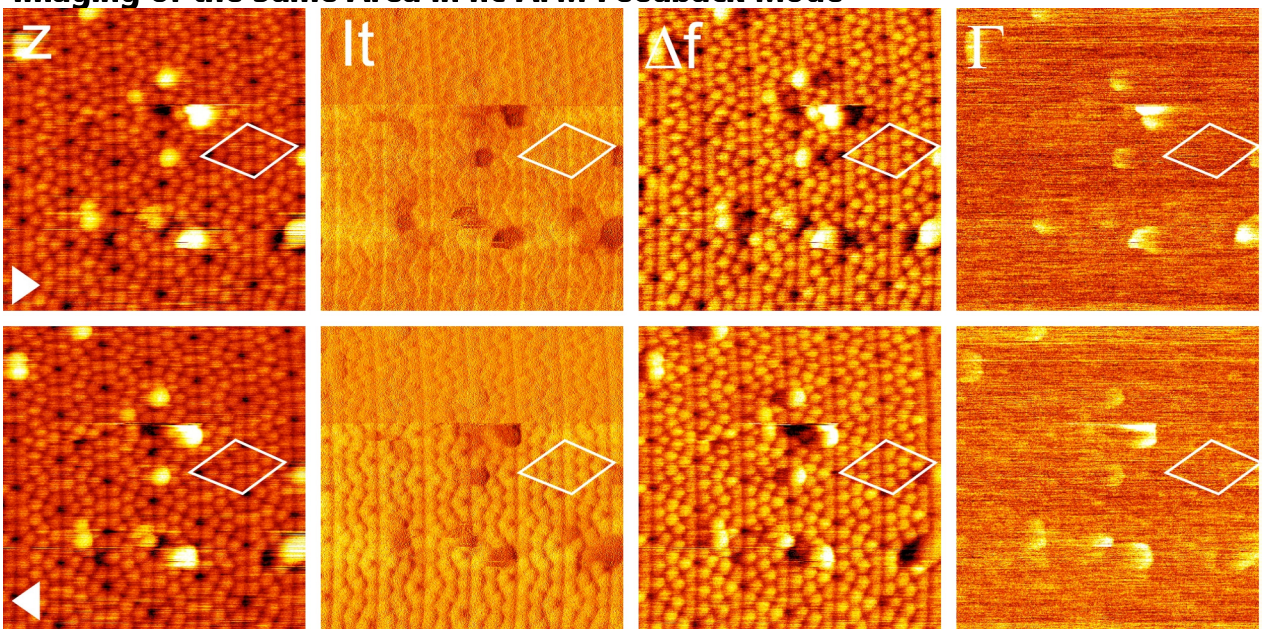


Figure 1: Successive STM and AFM feedback mode imaging of the same area
Image size: 15 nm x 15 nm, f_{res} = 996,577 Hz, Q= 17500, A = 200 pm, (512 x 512) pixels respectively
STM feedback mode: I=400 pA, U= + 0.95 V, imaging speed: 8.3 lines/s
AFM feedback mode: Δf = -0.3 Hz,, U_{CPD} = 0.070 V, imaging speed: 2.5 lines/s,
For orientation the same unit cell is marked by the rhombus in each image.

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Close-up View of Defects on the Surface

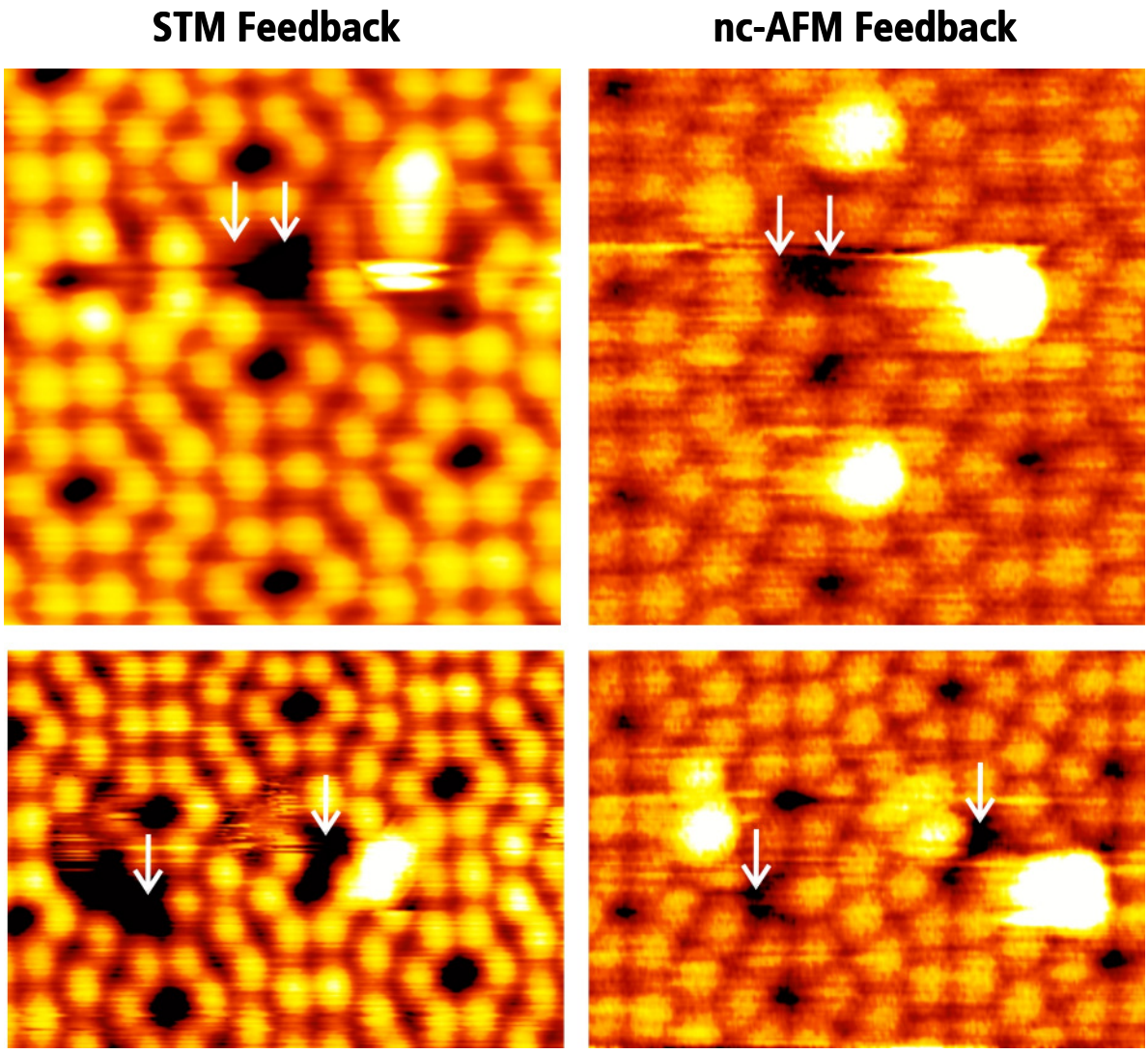

Figure 2: Identification of defects on the surface by combined imaging with STM and nc-AFM

Atomic size adsorbates and missing ad-atoms on the surface are imaged with STM and nc-AFM feedback mode. Arrows indicate positions of missing adatoms which can be unambiguously identified by comparison of both imaging modes. Interestingly in STM adsorbates are imaged mostly as depletions which likely results in a misinterpretation of these defects as vacancies in STM images. Typically these adsorbates cause also some glitches in STM images as shown above. Comparison of the same defects imaged in nc-AFM feedback mode allows to distinguish vacancies from adsorbates.

Imaging HOPG in STM and nc-AFM Feedback Mode

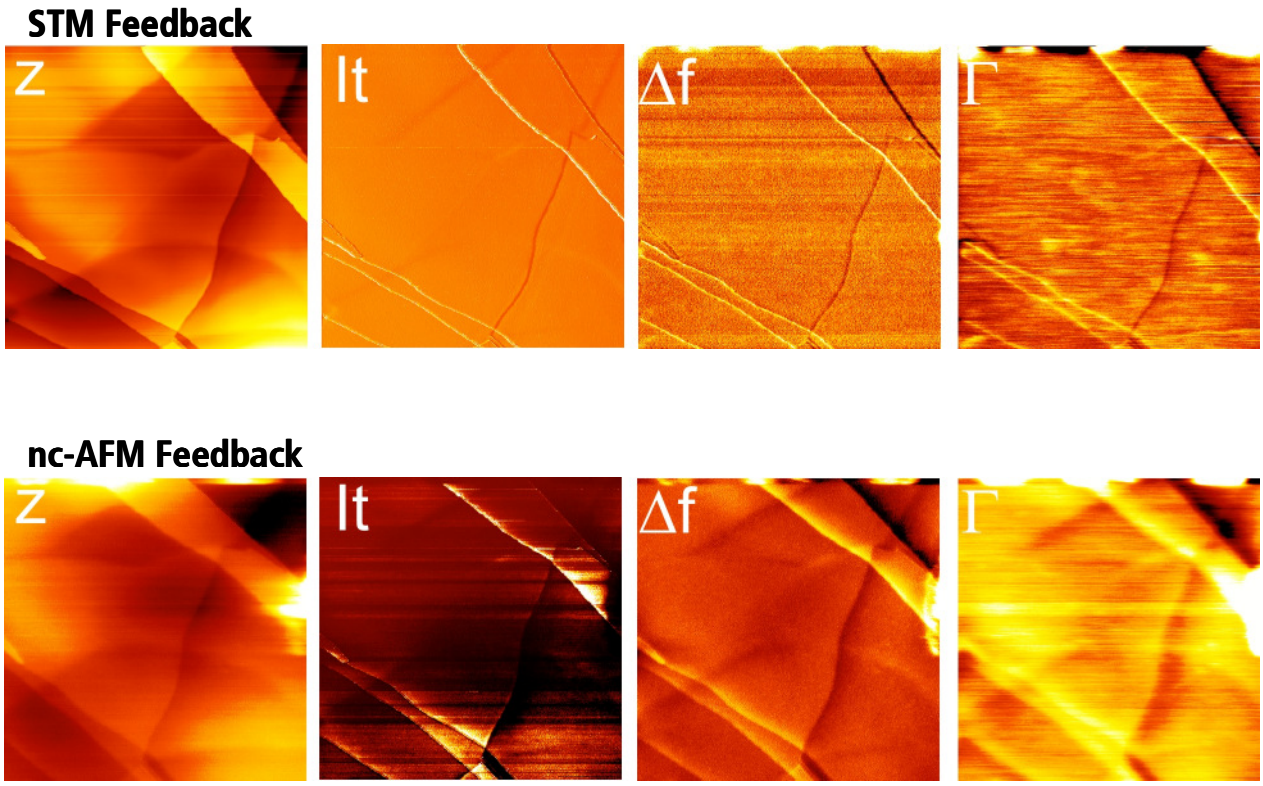

Figure 3: Imaging of the same area on the HOPG surface in STM and nc-AFM feedback mode

Topography and step heights are identical in both feedback modes. However, for studies of heterogeneous surfaces or structured substrates like moleuclar islands or metallic clusters and islands on conducting substrates comparison of both imaging modes may yield different step heights/contrasts.

Image size: 300 nm x 300 nm, f_{res} = 998,281 Hz, Q= 16000, A = 400 pm,
(512 x 512) pixels respectively
STM feedback mode: I = 200 pA, U= + 1.0 V, imaging speed: 3.3 lines/s
AFM feedback mode: Δf = +2.3 Hz, U = +1.0 V, imaging speed: 2.0 lines/s,

Imaging HOPG in STM and nc-AFM Feedback Mode

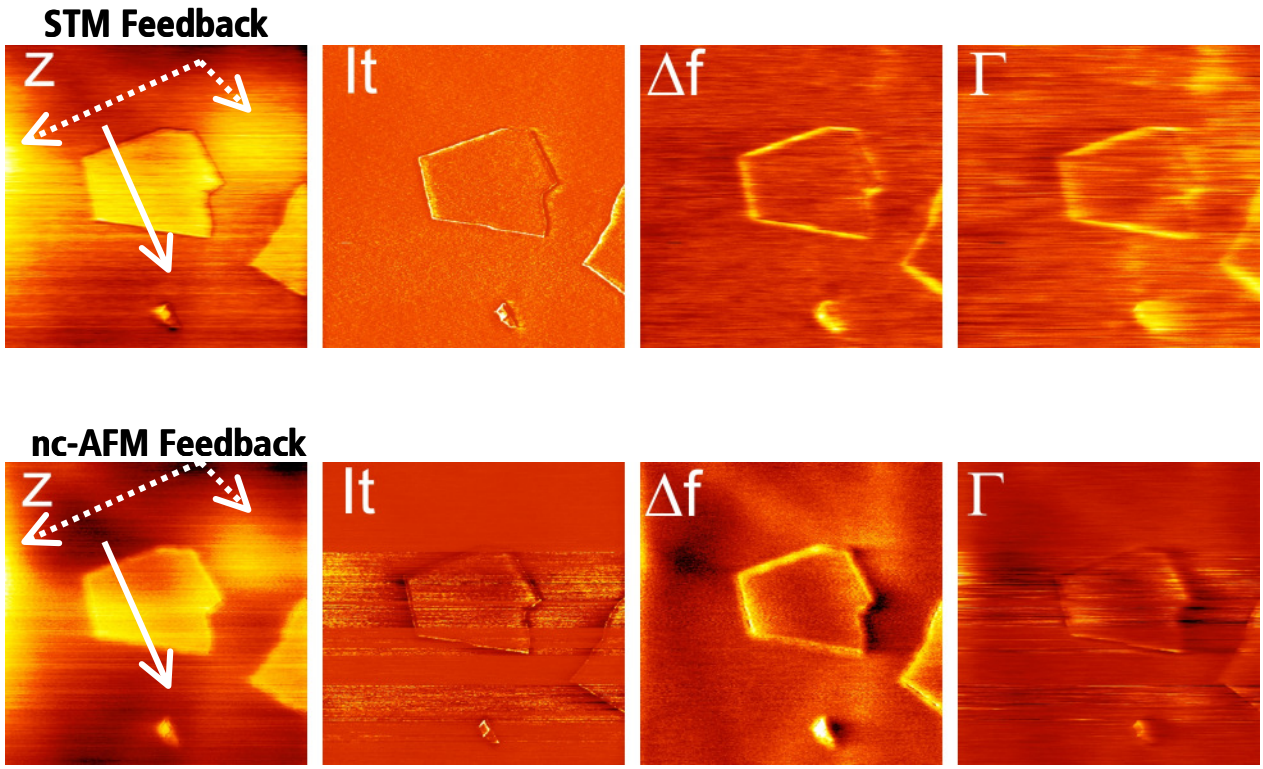

Figure 4: Imaging of the same area on the HOPG surface in STM and nc-AFM feedback mode

Topography and step heights are identical in both feedback modes as demonstrated in Fig. 5. Also noteworthy, the bright patches indicated by dashed arrows coincide for both images. This indicates that these patches are due to a surface relaxation in the graphite layers instead of e.g. charges in the subsurface layers.

Image size: 200 nm x 200 nm, f_{res} = 998,281 Hz,
Q= 16000, A = 400 pm, (512 x 512) pixels respectively

STM feedback mode: I = 200 pA, U= + 1.1 V,
imaging speed: 5.0 lines/s

AFM feedback mode: Δf = +1.6 Hz, U = +1.0 V,
imaging speed: 2.5 lines/s,

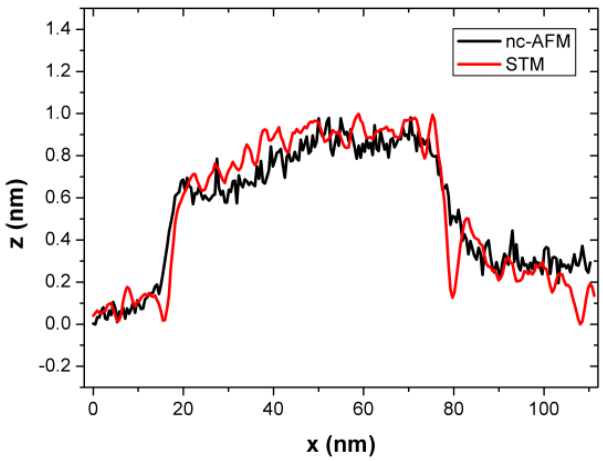

Figure 5: Topographic line profiles along solid lines in (z) images of Fig. 4

SPECS GmbH
Surface Analysis and Computer Technology
Voltastrasse 5
13355 Berlin · GERMANY

Phone: +49 30 467824-0
Fax: +49 30 4642083
E-mail: support@specs.de
http://www.specs.de