SPM 150 Aarhus with KolibriSensor®

Atomic resolution NC-AFM on KBr(001)

KolibriSensor®

Application Note

Among various insulators Potassium Bromide (KBr) has gained a lot of attention as a substrate for anchoring organic molecules [1,2]. This is due to the fact that on the cleaved KBr(001) surface, nanometer-sized and one-atomic-layer-deep pits can be created by electron irradiation with low energy electrons. These pits have been successfully used to trap different organic molecules leading to small, ordered agglomerates of molecules [1,2].

The KBr(001) surface has been studied at the atomic scale with the SPM 150 Aarhus with KolibriSensor® at room temperature.

- Large scale topographic images of the surface morphology of cleaved (irradiated) KBr(001) surfaces
- Highest quality atomically resolved images of the KBr(001) surface with a typical corrugation up to 70 pm
- Dependence of atomic contrast formation on tip polarity
- Imaging of atomic size defects on the surface

All 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.

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KBr(001) surface morphology

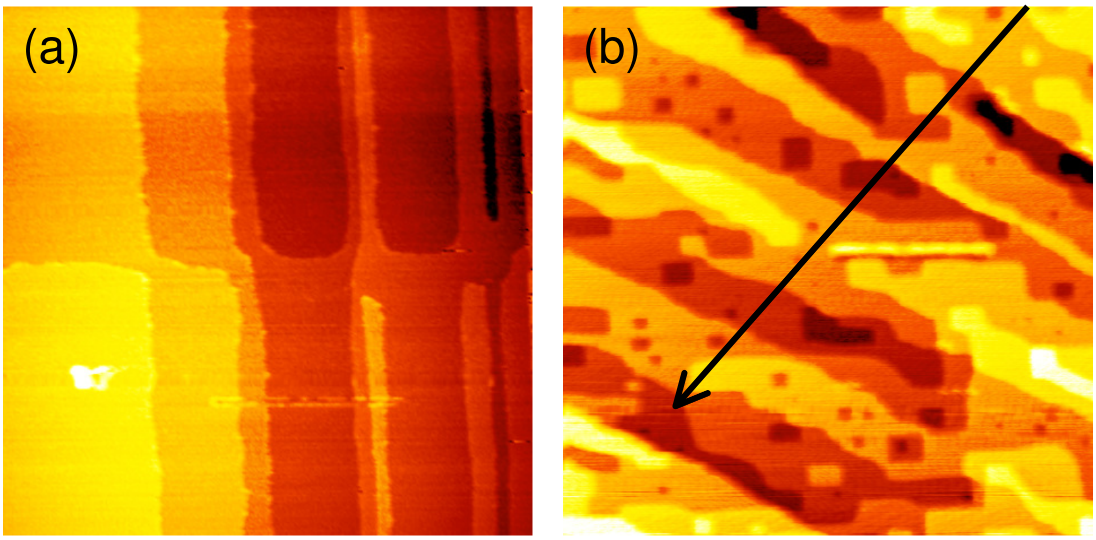

Figure 1: Large scale topographic images of cleaved KBr(001) surfaces. (a) measurements have been carried out with no filament operating in the UHV system. (b) filaments operating during experiments. In (b) the formation of rectangular pits is observed due to electron irradiation from the filament of the ion gauge onto the cleaved surface. No rectangular pits can be observed in (a) where the sample was investigated with all filaments switched off.

Image size: (350 nm x 350 nm), respectively, f_{res} = 997,386 Hz
(a) Δf = -0.3 Hz, A = 500 pm, U_{CPD} = 1.9 V, imaging speed: 1.5 lines/s
(b) Δf = -0.5 Hz, A = 600 pm, U_{CPD} = 1.7 V, imaging speed: 2 lines/s

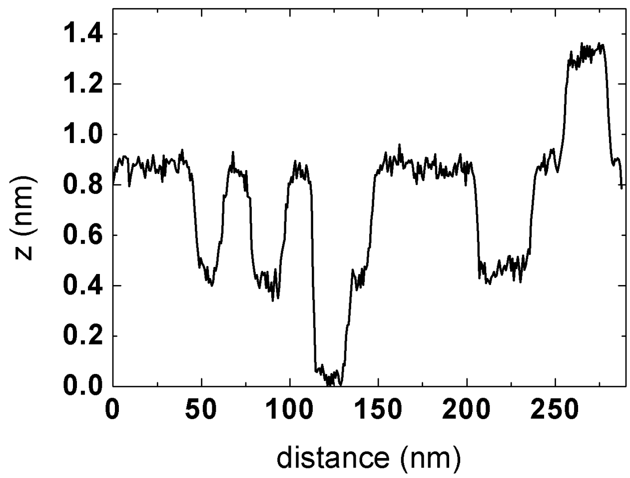

Figure 2: Height profile along the line indicated in Figure 1(b). Terraces are separated by atomic steps of about 380 pm height.

Highest quality atomic resolution imaging on KBr(001)

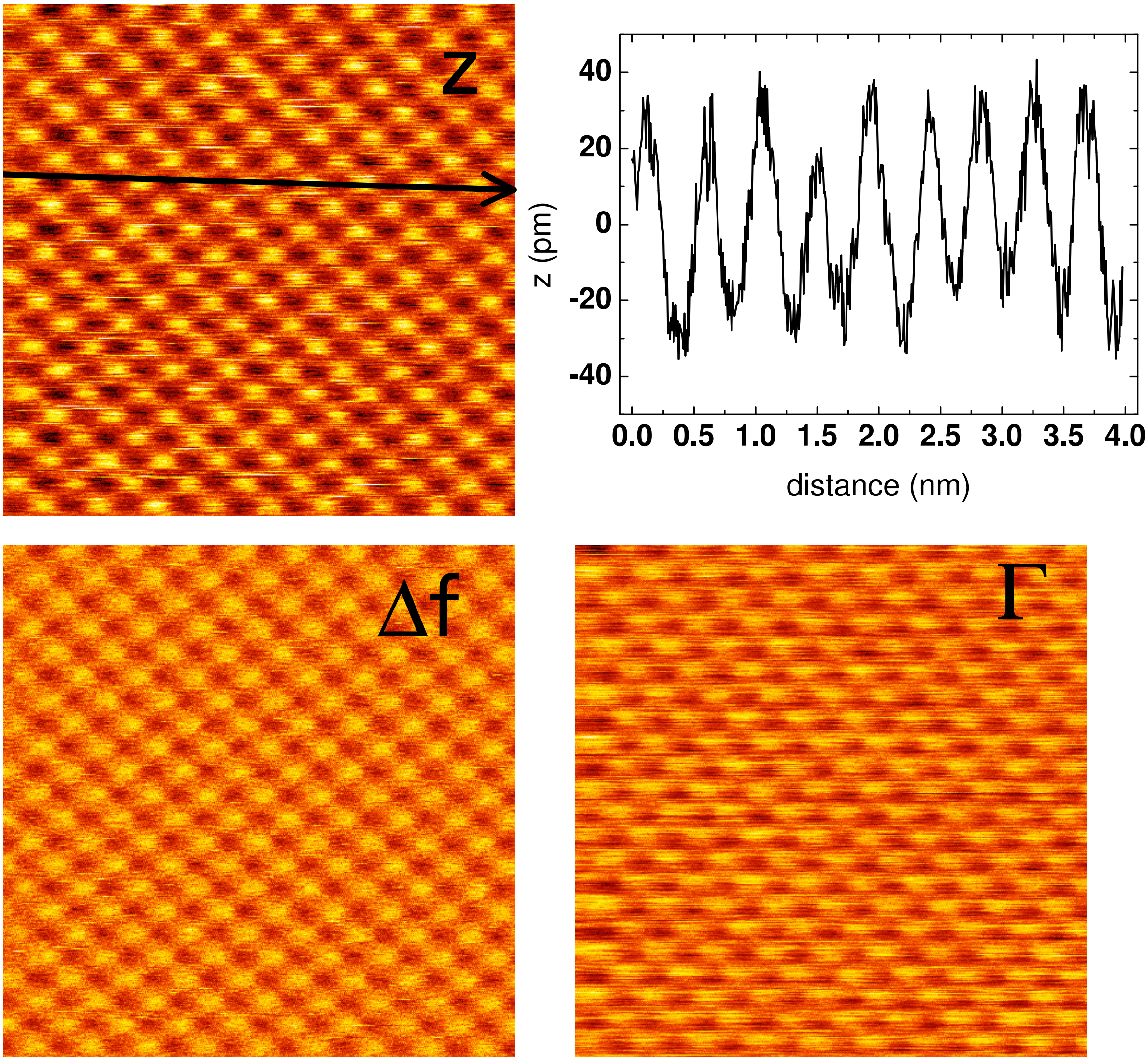

Figure 3: (z) Atomic resolution topographic image of the KBr(001) surface. Detuning (Δf) and dissipation (Γ) signals are recorded simultaneously. The Height profile reveals an atomic corrugation of about 70 pm.

Imaging parameters:
image size (4 nm x 4 nm), f_{res} = 999,110 Hz,
Δf = +0.24 Hz, A = 100 pm, U_{CPD} = 0.25 V,
imaging speed: 3.3 lines/s, 512 x 512 pixels

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Highest quality atomic resolution imaging on KBr(001)

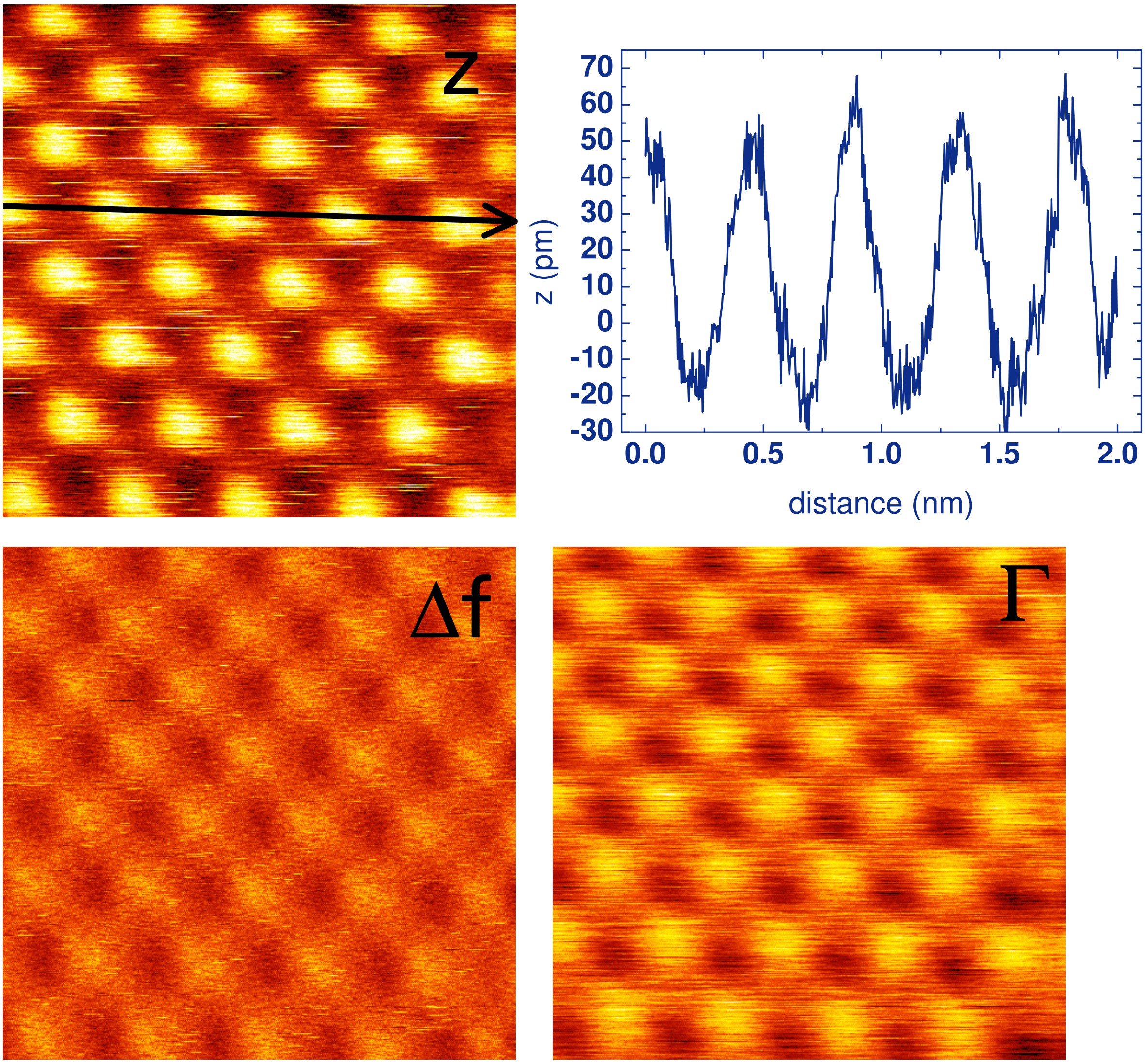

Figure 4: (z) Atomic resolution topographic image of the KBr(001) surface. Detuning (Δf) and dissipation (Γ) signals are recorded simultaneously. The Height profile reveals an atomic corrugation of about 70 pm.

Imaging parameters:
image size (2.5 nm x 2.5 nm), f_{res} = 999,110 Hz,
Δf = +0.24 Hz, A = 100 pm, U_{CPD} = 0.25 V,
imaging speed: 3.3 lines/s, 512 x 512 pixels.

Dependence of the atomic contrast formation on KBr(001) on tip polarity

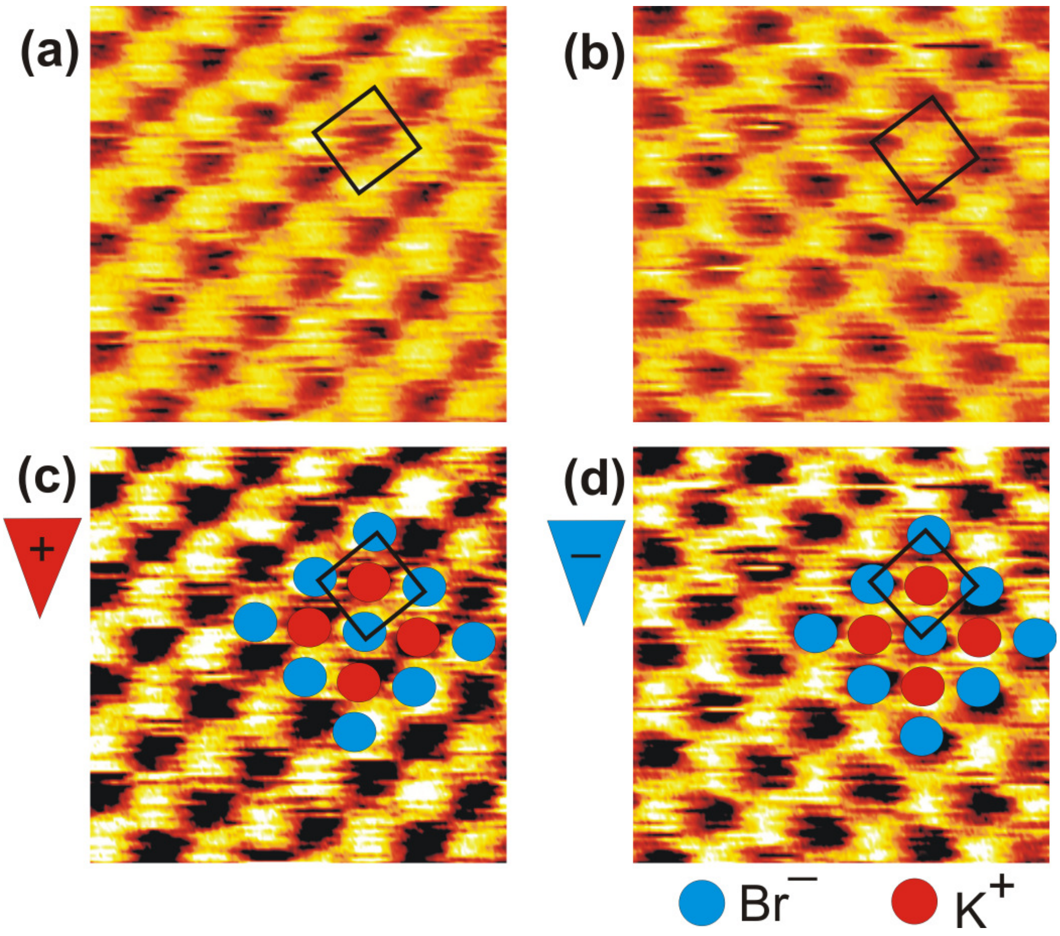

Figure 5: Atomic resolution topographic images of the KBr(001) surface revealing two types of contrast (a) and (b). The contrast formation on this surface depends on the polarity of the tip apex [3,4]. Presumably atomic resolution imaging is achieved by picking up a polar KBr cluster at the tip apex. The tip polarity of this cluster then governs the contrast formation [3,4] imaging either K^+ or Br^- ions in the terminating (001) layer as bright protrusions. A suggested model for the tip polarities together with a superimposed model of the KBr(001) surface is shown in figures (c) and (d).

Imaging of atomic size defects on the KBr(001) surface

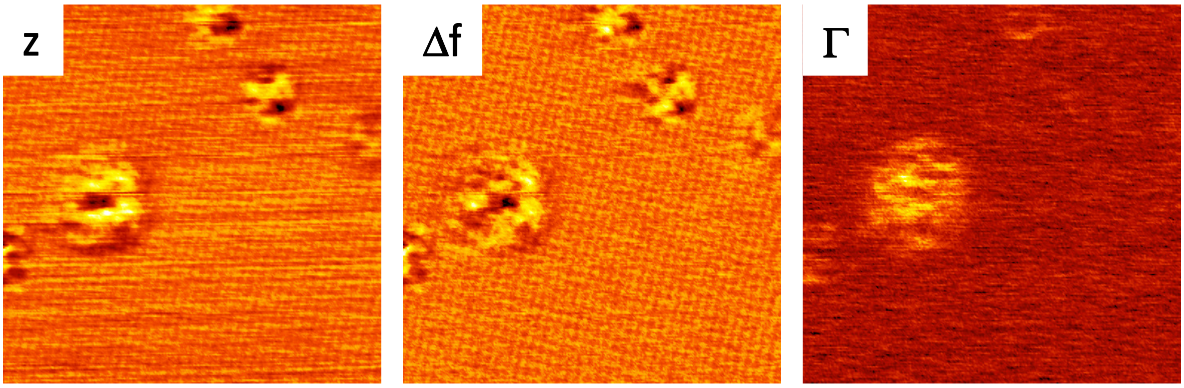

Figure 6: Imaging of defects on the surface whereas atomic resolution is obtained throughout the image. Atop the defective areas enhanced dissipation (Γ) is registered.
Image size (10 nm x 10 nm), f_{res} = 996,035 Hz, Δf = +0.30 Hz,
A = 100 pm, U_{CPD} = 2.03 V, imaging speed: 2 lines/s.

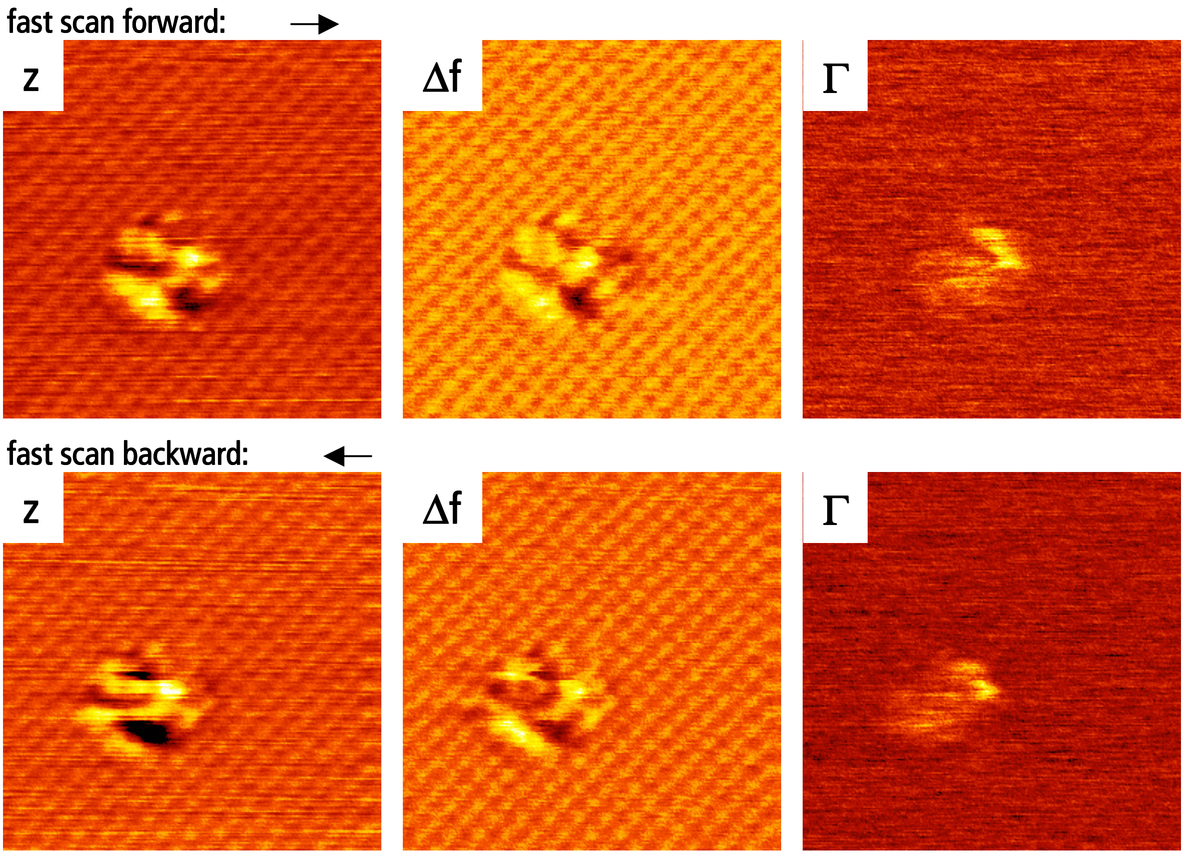

Figure 7: Zoom on a defective area on the surface with comparison of forward and backward fast scan direction. The shape of the defect is identical in both directions.
Image size (4 nm x 4 nm), f_{res} = 996,035 Hz, Δf = +0.33 Hz,
A = 100 pm, U_{CPD} = 2.03 V, imaging speed: 2.5 lines/s

References

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[2] Observation of Individual Molecules Trapped on a Nanostructured Insulator
L. Nony, et al., Nano Lett., **4** (11), 2185 (2004)

[3] Sublattice Identification in Scanning Force Microscopy on Alkali Halide Surfaces
Hoffmann R., et al., Phys. Rev. Lett., **92** (12), 146103 (2004)

[4] Atomic resolution imaging and force versus distance measurements on KBr(001) using low temperature scanning force microscopy
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