The JPK Kelvin Probe Microscopy (KPM) module for the NanoWizard® AFM

Kelvin Probe Microscopy (KPM also abbreviated as KPFM, KFM, SKM), is additionally known as electric potential microscopy (EPM). This SPM technique quantitatively maps the difference in work functions on conductive or non-conductive surfaces. AFM topography can be recorded simultaneously to the KPM signal.

The Kelvin Probe microscopy principle

In order to measure the surface potential of the sample a DC voltage superimposed with a sinusoidal AC voltage is applied to the tip, while the sample is grounded.
Due to the acting coulomb forces between tip and sample the cantilever starts to oscillate with the frequency of the applied AC voltage. The amplitude of the resulting oscillation of the cantilever depends on the difference between the applied DC voltage and the surface potential of the sample to be investigated. The oscillation of the cantilever becomes minimal, when the applied DC voltage is adjusted in such a way that it equals the potential (work function) of the sample. Thus, the applied DC voltage is a measure for the surface potential of the sample.

Setup description

The KPM hardware from JPK comes as a small electronic box that can easily be connected to the JPK AFM controller via the Signal Access Module (SAM) (Figure 1). The cantilever is electrically contacted by a conductive spring clip that is connected to the KPM module

Electrically conductive Pt/Ir coated cantilevers can be used for Kelvin probe microscopy. Alternatively, doped Si cantilevers can successfully applied since there is no current flow through the cantilever during a KPM experiment.

Fig. 1 *JPK's KPM module, to be connected to the NanoWizard® controller*

Application fields

The technique can be used to image samples that possess a distribution of electrical properties on inhomogeneous materials as well as on nanostructures.

Application overview:

- Thin film investigation
- Nanoparticles and wires
- Composites and powders
- Light emitting polymer films
- Organic photovoltaic systems
- Semiconductor quality control
- Corrosion
- Potential mapping of biomaterials
- Biocompatible coatings
- Bionics
- Surface modifications

In Figure 2 a measurement is shown with the JPK Kelvin Probe module on an interdigitated electrode sample. The sample consists of two parallel comb-shaped chromium electrodes, which were printed onto a glass slide by an evaporation process. Voltages of ±10 V can be applied to either of the electrodes during the experiment.

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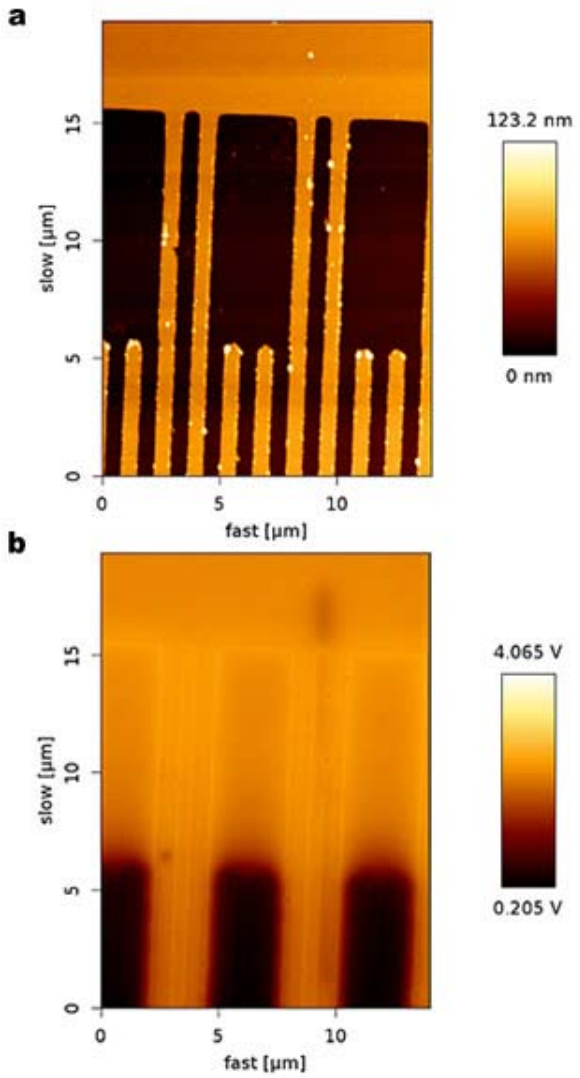

Fig. 2 *Topography (a) and KPM (b) image of interdigitated electrodes. Image size 22.4 x 14 µm. Applied voltage to the electrodes 0 and 4.5 V. Si cantilever, beam type, spring constant 3 N/m*

Figure 2a illustrates the topography of the electrodes. Multiple pairs of slim electrodes are connected with the bulk electrode in such a way that every second digit pair comes from the adjacent bulk electrode. The white dots are corroded electrode material.

The corresponding KPM image (Figure 2b) shows that the bulk electrode and the corresponding digits exhibit the same KPM voltage of 4.5 V. The uncovered glass surface exhibits a totally different voltage value. The narrow open glass planes between the digits are not clearly resolved due to the inhomogeneity of the electric field formed between the sample planes and the tetrahedral AFM tip

Features and benefits

The JPK Kelvin Probe AFM modules support experiments under ambient conditions in air and under other environmental conditions (other gases than air). Full compatibility with existing JPK products guaranties straight-forward experimentation. The KPM modules can be used together with all NanoWizard® AFM heads. The JPK software provides a lot of features for Kelvin Probe imaging, point spectroscopy and manipulation.

The JPK Kelvin Probe modules provide full optical access to the sample on inverted and upright microscopes. They can be used together with the JPK TopViewOptics™ and the Biomaterials Workstation® (BioMAT).

Together with JPK temperature stages HTHS™ (ambient up to 300 °C), HCS™ (0 to 100 °C) and HCM™ (-35 to 120°C), the sample can be heated or cooled for KPM experiments.

Specifications

- External bias electronics module (±10V)
- Can be operated on opaque and transparent samples
- Sample holder for transparent samples (e.g. ITO substrates) works with all inverted optical microscopes
- Compatible with all NanoWizard AFM´s
- Easy to use software interface

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