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Applications of Tactile Microprobes for Surface Metrology

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Summary:
In this paper we discuss the capabilities of micromachined piezoresistive silicon cantilevers regarding their application for surface metrology [1]. Measurements were performed using contact-mode Atomic Force Microscopy (AFM) and contact-resonance mode, respectively [2]. The contact-mode AFM measurements were carried out inside a Scanning Electron Microscope (SEM) vacuum chamber enabling correlative scanning probe and electron microscopy [4].

Keywords: piezoresistive cantilever, MEMS, atomic force microscopy, contact resonance, surface roughness

Microprobe Sensor

Piezoresistive cantilever sensors have become a versatile tool for measuring the mechanical properties, the topography and the surface roughness of various materials [1,2]. A SEM image of the probe used within this paper is shown in Figure 1.

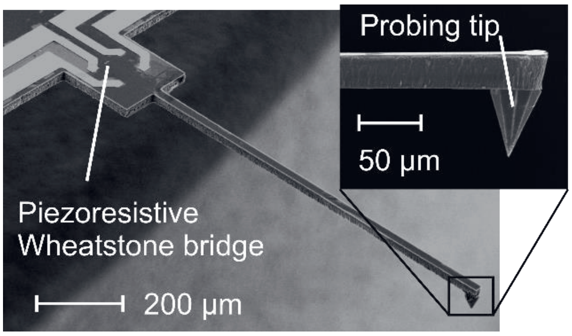

Fig.1. SEM image of a 1.5mm-long microprobe [1].

The probe is commercially available (CAN series, CiS Forschungsinstitut für Mikrosensorik GmbH, Erfurt/Germany) in different lengths ranging from 1.5mm up to 5mm. The slender structure of the cantilever allows to inspect surfaces inside cavities and narrow milling grooves which aren't accessible with other tools [1,2]. The probe features a height sensitivity of 50pm/√(Hz) which leads to an achievable imaging resolution below 10nm [3].

Correlative AFM and SEM Measurements

Combining the AFM-based topography and roughness measurements of the microprobe with a SEM offers several advantages. Not only can the SEM be used for wide range coarse navigation on the sample, it also allows to simultaneously monitor the tip-sample interactions during the AFM scanning process.

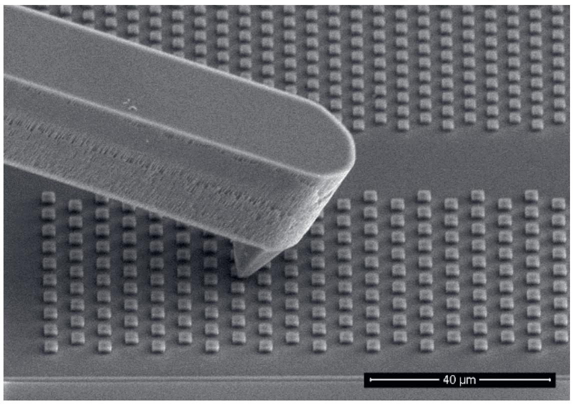

Fig.2. Contact-mode AFM imaging combined with SEM imaging.

Moreover is it possible to constantly observe the tip-wear of the probe, which is especially for high accuracy surface roughness measurements beneficial. The vacuum-compatible AFM (AFMinSEM, nano analytik GmbH) we used for measurements features a coarse positioning unit for moving the probe in an area of interest of 18mm x 18mm. Additionally, a capacitive closed loop scanner for high resolution imaging is used as a sample nanopositioning stage with a scanning range of up to 60µm x 60µm x 20µm in X-, Y-, Z-direction.

Contact Resonance Spectroscopy (CRS)

Contact Resonance Spectroscopy (CRS) is an operation mode of AFMs where the amplitude and phase response of a resonant-excited cantilever probe is recorded to detect sub-surface features of materials via its contact stiffness and damping. Using the piezoresistive CAN sensor, the range of work pieces to be characterized using CRS could be extended to high-aspect-ratio (HAR) geometries [5]. Here a chip-size piezo actuator (PL055.30 by Physik Instrumente) is mounted below the CAN chip corresponding to the configuration of ultrasonic atomic force microscopy (UAFM) operation mode in AFMs. It was shown that CAN-sensor-based CRS is sensitive enough to show a contrast of ~ 15-nm-thick layers of PEDOT on silicon [6]. For further performance evaluation a modified probe- holder and interface printed circuit board (PCB) was designed and fabricated for operation of the CAN-sensor-based CRS in a Cypher AFM (Asylum Research) (Fig. 3).

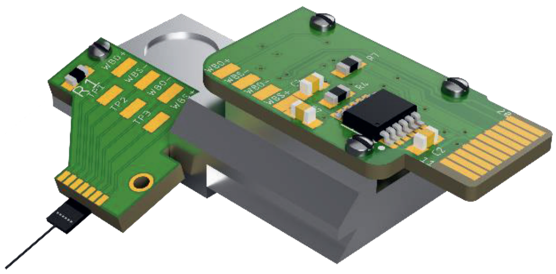

Fig.3. Schematic of a CAN50-2-5 probe holder with pre-amplifier and interface PCB for operation in a Cypher AFM.

Results

Within this work we presented the capabilities of the microprobe integrated in two different setups each with unique functionalities. The integration into the AFMinSEM in enhancing its functionalities with standardized roughness measurements and allowing measurements to be taken in areas that standard cantilevers are normally withheld.

Acknowledgements

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