FIRAT: A new AFM probe for fast imaging, material characterization, and single molecular mechanics

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Abstract: A new AFM probe, called the force-sensing integrated readout and active tip (FIRAT), is described and initial experimental results on fast imaging, quantitative material characterization at nanoscale, and single biomolecular mechanics measurements are presented. FIRAT combines a micromachined integrated electrostatic actuator to move the tip and an integrated optical interferometric displacement detector in a microscale volume. The current implementation of the probe uses surface micromachined membrane and beam structures on quartz substrate as the mechanical force sensing structure, and the probe tips are fabricated by focused ion beam assisted deposition. Interferometric detection is achieved by monitoring the reflected diffraction pattern generated when the diffraction grating shaped actuator electrode is illuminated by a laser. This robust interferometer structure has been shown to provide detection levels of 10fm/√Hz down to 3Hz, operating close to the shot noise level. The probe is already integrated to commercial AFM systems for imaging and material characterization experiments. The results indicate the potential to increase the tapping mode imaging speed up to 100 times as compared to commercial AFM systems. When used in the time resolved interaction force (TRIF) mode, the FIRAT probe provides quantitative information such as surface adhesion and elasticity through model based inversion, while simultaneously imaging the topography. TRIF mode images and inversion results on various polymer and carbon nanotube samples are obtained. Finally, FIRAT probes for biological applications are described and initial results on single molecule force spectroscopy are presented.

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