# SMALL SiN AFM CANTILEVERS FOR HIGH FREQUENCY APPLICATION

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'Real-time' nanoscale imaging and single molecule force spectroscopy of bio-chemical specimen based on atomic force microscopy (AFM) requires cantilevers with *both* low force constant and high-resonant frequency. The required spring constant should be between 1-5 pN/nm and the resonance frequency above 100 kHz for such applications.

This project aims the development and fabrication of small cantilevers with aforementioned characteristics. Testing and analysis has been done on an in-house made AFM-system [1].

Standard micromachining techniques with bulk silicon micromachining are not readily applicable to obtain the required small (~ 10-25 µm long) and thin (200 nm) $SiN_3$ cantilevers. One of the reasons is that a wet-etch release-step, which is quite common for stiff cantilevers, is excluded in our case since sticking of the soft, low spring-constant cantilevers has to be avoided. The fabrication process is based on a new surface micromachining method, where the negative epoxy resist SU-8 is forming the body of the probe. The cantilevers are made from low stress LPCVD $SiN_3$, guaranteeing straight cantilevers upon release.

Figure 1 shows a SEM image of the AFM probe after release. The SU-8 body has a hexagonal structure that allows rapid lateral underetching by a fluorine chemistry of the silicon sacrificial layer [2]. Furthermore, the reduced volume due to the hexagonal structure helps reducing the mechanical stress in the SU-8 body while maintaining its rigidity. The cantilevers are attached to a ~5 µm-thick layer of SU-8 which enables the laser-light to access the cantilevers for AFM feedback operation (see figure 1). After the release of the probe, a 10-20 nm thick layer of Al is evaporated to enhance optical reflection.

Cantilevers with dimensions of 15-25um length, 3-5um width and a thickness of approximately 200nm, variable due to processing have been characterized using interferometry. A typical value of the resonance frequency for such cantilevers under ambient conditions was measured around 450 kHz as shown in figure 2. The spring constant is around $5.10^{-3}$N/m, using the thermal fluctuation calibration method [3].

High resonant frequency in ambient condition (445 kHz) and liquid (135 kHz) enables fast scanning in the imaging mode and pulling in the force spectroscopy mode. In contrast, a 200 um long commercially available cantilever has a resonant frequency of only 4 kHz in liquid [4].
A future process includes probes with sharpened tips, which allows high resolution imaging of biological samples.

**References:**


[1] J. Martini et al., Small Cantilever AFM for Single Molecule Force Spectroscopy, DPG Frühjahrstagung, 2004, Regensburg

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[3] J. L. Hutter, J. Bechhoefer, Calibration of atomic force microscope tips. Rev. Sci. Instr. 64 (7) July 1993

[4] M.B. Viani et al., Fast imaging and force spectroscopy of single biopolymers with a new atomic force microscope designed for small cantilevers, Rev. Sci. Instr. 70 (10) November 1999


**Figures:**

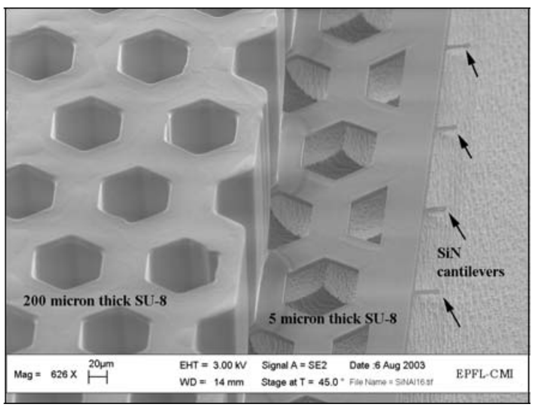


Figure 1: SEM image of 4 SiN AFM-probes (20 µm long, 200 nm thick) attached to SU-8 body.

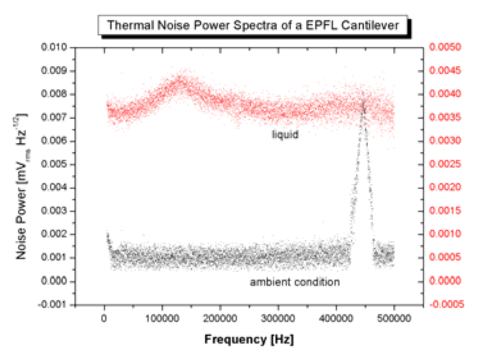


Figure 2: Typical power spectrum of a 17um long, 4um wide and 200nm thick SiN cantilever. The resonance frequency is around 450 kHz under ambient condition