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4.8 MHZ AFM NANOPROBES WITH CAPACITIVE TRANSDUCERS AND BATCH-FABRICATED NANOTIPS

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High speed Atomic Force Microscopy (AFM) and potential applications in biology need to increase the resonance frequency of the probes which is limited to a few megahertz for standard cantilevers [1]. We report here on 4.8MHz MEMS-based laserless AFM probes with integrated nanotips and 80nm capacitive transduction gaps. Device integration in AFM set-up leads to AFM images using high resonance frequency Nanoprobe.
A silicon ring with an external radius of 30µm and an internal radius of 25µm is designed taking care of the integration of a prominent nano-tip. AFM nanoprobes are fabricated using standard silicion microtechnologies combining surface micromachining of thin films, bulk micromachining of the substrate and anisotropic wet etching. Small gaps being critical to maximize the capacitive transduction, 80nm capacitive gaps are obtained by using thin sacrificial layers. A chemical wet etching defines the in-plane nanotip, yielding to a tip apex radius of 10 to 20nm typically. The final HF etch releases both capacitive gap and resonating structure (fig. 1a) [2].

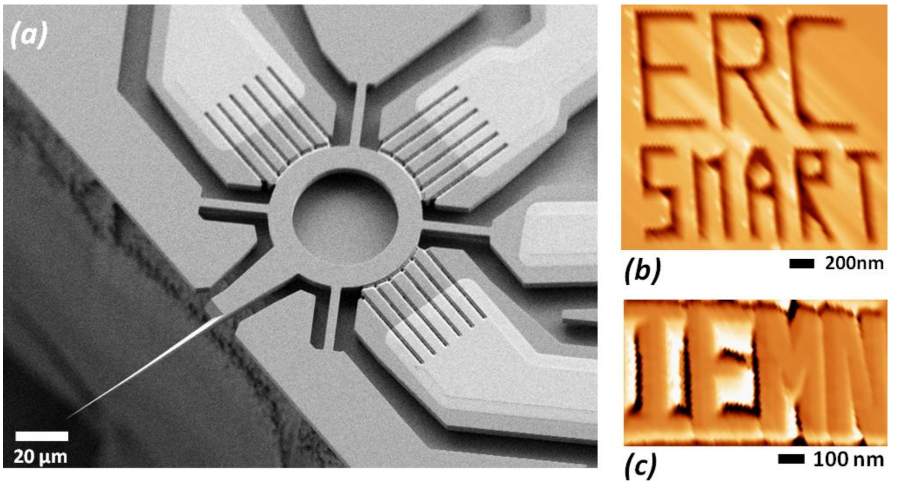

Fig. 1: (a) *SEM pictures of a AFM Nanoprobe. The ring is anchored at the four nodes of the elliptic resonance mode and three capacitive electrodes can be used. The prominent tip is suspended thanks to the back side etch.(b)& (c) 2D topographic images of 100nm width trenches (b) and lines of resist (c) (thickness=110nm) on silicon substrate obtained with the Nanoprobe in Tapping Mode at 4.8MHz.*

Electrical frequency response of the device is obtained using a vectorial network analyzer and shows a resonance frequency at 4.8MHz as expected. The probe holder of a Multimode Veeco microscope is replaced by a dedicated circuit board holding the MEMS nanoprobe. A Nanonis controller drives the ring resonator and processes its output signal thanks to a lock-in amplifier and controls the XYZ Veeco scanner. The tip-surface distance is adjusted so as the nanoprobe to interact with the surface in intermittent contact regime. By scanning the X and Y axis and acquiring the Z regulation signal, topographic images of the sample surface are obtained. Figures 1b and 1c present respectively 2x2µm and 2x1µm images of 110nm thick resist patterns on a silicon substrate. 100nm wide trenches (fig. 1b) and lines (fig. 1c) are imaged. For this probe, the minimal detectable force is estimated to be 5pN.$Hz^{-1/2}$, which paves the way for the observation of soft materials and biological samples. Moreover, the high resonance frequency of the AFM Nanoprobes would allow extended measurement bandwidths, leading to High-Speed AFM and time-resolved measurement of dynamic phenomena. Future works concern both the integration of the MEMS Nanoprobes in high speed AFM set-up and a further downscaling of the devices for higher operation frequencies and enhanced performances.

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References

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[2] Walter, B., Faucher, M., Mairiaux, E., Xiong, Z., Buchaillot, L., & Legrand, B. (2011). *Proceedings of the IEEE International Conference on Micro Electro Mechanical Systems (MEMS),* 517-520.

Je souhaite concourir au prix présentation orale et je déclare être un chercheur non-permanent ayant n'ayant pas encore soutenu la thèse.