Micromachined Video Rate AFM Silicon Cantilever

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Atomic force microscopy (AFM) have been used to image bacteria, viruses and DNA molecules, often at the level of single objects, and have shown great potential for a variety of sensing applications in life science, chemical- and biological research. The slowing factor of AFM imaging is the scan speed – whereby the time for one image can rise up to few minutes. The scan speed is once dependent on the image properties (resolution, scan area) and second to the physical boundaries of the AFM cantilever. Standard AFM cantilever have sizes in 100µm-scale and using optical read out to project the topography of the sample. More commercial usage of AFM technology would be reached, if it would be possible to generate video sequences by strung-together many (up to 35) single images per second. Therefore the image generating process (data sampling rate) have to be speed up. To achieve this issue the oscillating rate must be in the range of MHz ($\sim 10^6$ data points per second). Such a high oscillating frequency is required to generate images in milliseconds (ms) to obtain video quality with nanometer resolution.

We developed micromachining process for shrinking the physical dimensions down to nanometer scale[1]. By decreasing the physical dimensions - the cantilevers weight reaches attogramm (ag – 10^{-18}g) with resonance frequency ranging from 20- up to 150 MHz[2]. The video cantilever are based on silicon on insulator (SOI) technology and were defined with e-beam lithography (Raith150-System) by using hydrogen silsesquioxane (HSQ) - a negative e-beam resist which is acting as perfect etching mask stable to fluorine based plasma environments. The video cantilever beams brought into electrical contact with metal contact pads. Employing integrated electronic displacement transducers based on piezoresistive readout, allowing simple and optimal video signal readout. A final gently isotropic hydrofluoric acid vapor (HFV) etch technology was performed to etch free (in air) standing video cantilevers. We achieved 27nm thin free standing nano-sized cantilever with geometrical dimensions of only 650nm in total length, 350nm in total width - with a beam width of only 16nm.

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[1] M. Hofer, Th. Stauden, I.W. Rangelow and J. Pezoldt: Mater Sci. Forum Vols. 645-648 (2010), 841

[2] M. Hofer, Th. Stauden, S. A. K. Nomvussi, J. Pezoldt, and I.W. Rangelow, in *Proceeding of the 15th ITG/GMA-Conference, VDE Verlag, 2010*, p330

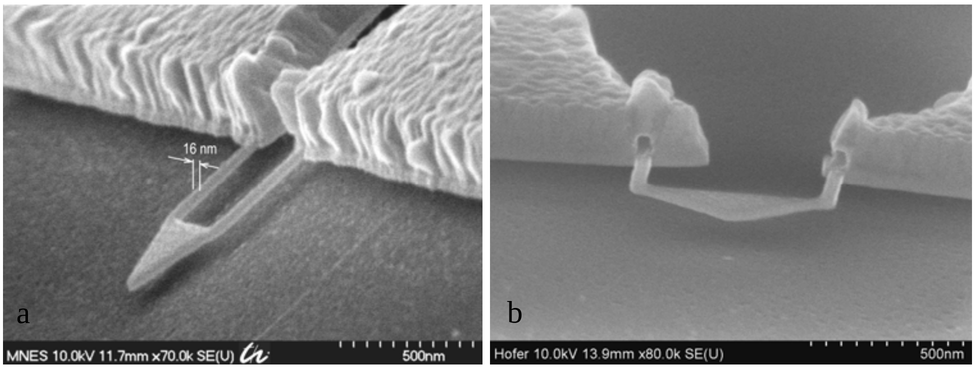

Figure 1: Free standing silicon nano cantilever: (a, b) The single crystal Silicon nano cantilevers. The physical dimensions are 650 nm length and 350 nm width. The width of the two beams is only 16 nm. On top of the contact pads 280 nm Al used for ohmic contact.

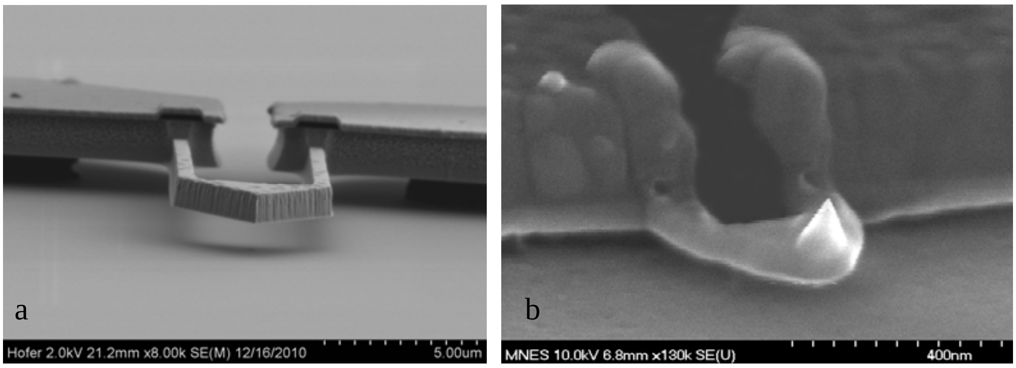

Figure 2: Single crystal Silicon video cantilever: (a) The physical dimensions of the silicon video cantilever are 15 µm in length, 3 µm of width and 1µm thickness. The beam width is 0.8 µm. On top a 300 nm thin Al layer is performed for ohmic contact for an electrical excitation and read out of the sensors signals; *(b)* Single crystal Silicon video cantilever with Electron Beam Induced Deposited (EBID) tip.