Ultrafast Cantilever for High Speed Scanning Force Microscopy

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High Speed Atomic Force Microscope imaging is important for many applications not only in biology, where the ability to follow processes occurring in the millisecond regime at the molecular level is a major goal. High speed imaging also allows greater areas of specimen to be examined in a given time, and it allows the pattering of surfaces over useful areas on a practical timescale for the creation of nanostructures.

The sampling frequency is direct proportional to the resonance frequency of the cantilever. The resonance frequency (ω) of an undamped cantilever is given by: $\omega = (k/m)^{1/2}$, with k the spring constant and m the effective mass of the cantilever. To achieve resonance frequencies in the MHz Range- in this case 0.5-2 MHz - it is necessary to reduce the mass and with this the physical dimensions of the system. Additionally the spring constant of the resonator has to be optimizes for a proper cantilever deflection. Here we will briefly present the design and fabrication of a high resonance frequency cantilever with out- of-plane tip. The cantilever contains both an integrated piezoresistive silicon sensor and an integrated bimorph actuator. The integration of sensor and actuator on a single cantilever will allow, in the future, creating cantilever arrays for simultaneous record of AFM images in the dynamic mode.[1]

Such MHz Cantilever, with resonance frequency between 0.5- 2 MHz (Fig. 1), is fabricated in a Bulk- silicon micromaching process. The cantilever is defined with a KOH etching process followed by an advanced silicon etching process (ASE) to release the Cantilever. The piezoresistors are formed by ion implantation, followed by thermal annealing for the electrical activation. The electrical contacts and the bimorph actuator are made out of aluminum. Fig. 2 shows, a free standing cantilever with a measured resonance frequency of 485 kHz.

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[1] Sarov, Y. ; Frank, A. ; Ivanov, Tzv. ; Zoellner, J.-P. ; Ivanova, K. ; Volland, B. ; Rangelow, I. W. ; Brogan, A. ; Wilson, R ; Zawierucha, P. ; Zielony, M. ; Gotszalk, T. ; Nikolov, N. ; Zier, M. ; Schmidt, B. ; Kostic, I.: Parallel proximal probe arrays with vertical interconnections. In: Journal of Vacuum Science & Technology B: Microelectronics and Nanometer Structures 27 (2009), Nr. 6, 3132.

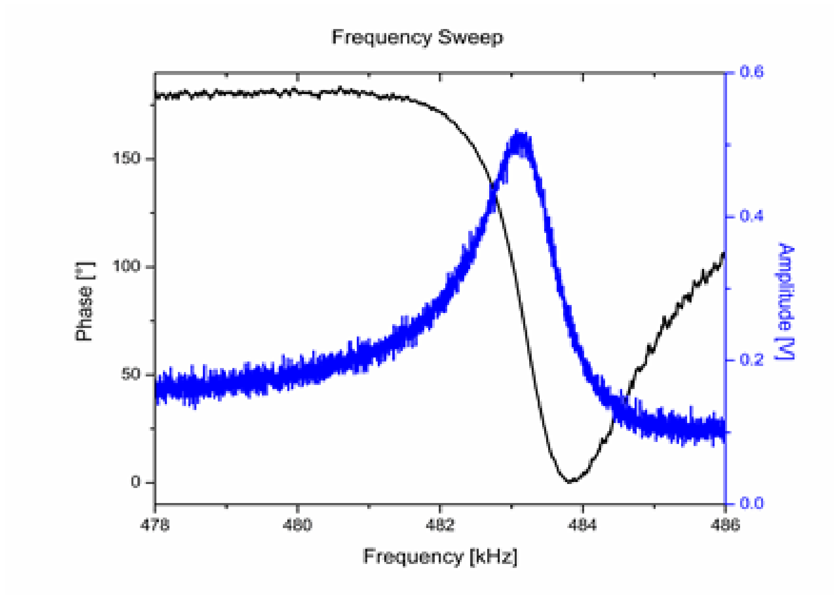

Figure 1: Resonant peak in amplitude vs. frequency chart

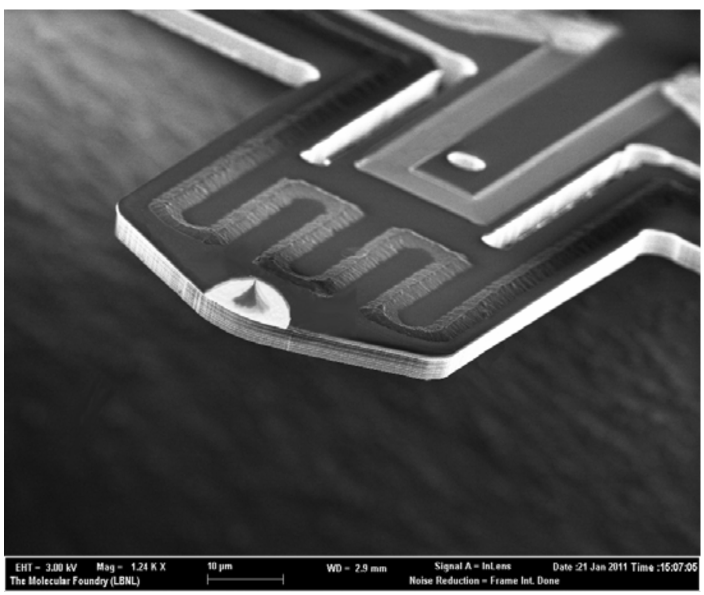

Figure 2: Released MHz Cantilever