Multi-Frequency Response from a Designed Array of Cantilevers

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Nanoelectromechanical systems (NEMS) such as resonating cantilevers are actively investigated for the use as mass sensors in the fields of chemistry, biology and medicine[1,2]. By reducing the dimensions of the cantilevers, sensitive detection and identification of low analyte concentration can be achieved. In addition, in an array format more than one specific molecular interaction can be detected simultaneously[3]. In this work, we have investigated a novel concept associated with the detection of the simultaneous multi-frequency response from an array of geometrically different cantilevers. We denote this method MFSAC: Multi-Frequency Signal analysis from an Array of Cantilevers[4]. Our nanomechanical oscillator arrays were fabricated from (001) Si-cantilevers. Using a Ga^+ focused ion beam (FIB), the original cantilevers were machined into two and three smaller cantilevers, respectively (Fig 1).

A laser beam is focused on all the cantilevers simultaneously, and reflected off to a position sensitive detector (PSD). The generated frequency spectrum shows each frequency peak corresponding to the specific cantilever (Fig 2). This provides a novel true label-free method to simultaneously detect the frequency response from several different cantilevers instantaneously in a single measurement. When the array is exposed to a certain mass load, the cantilevers report in a true label-free fashion their individual change in resonance frequencies being simultaneously detected in concert. The difference in $\Delta f / f_0$ for the different long cantilevers was found to be less than 0.1%.

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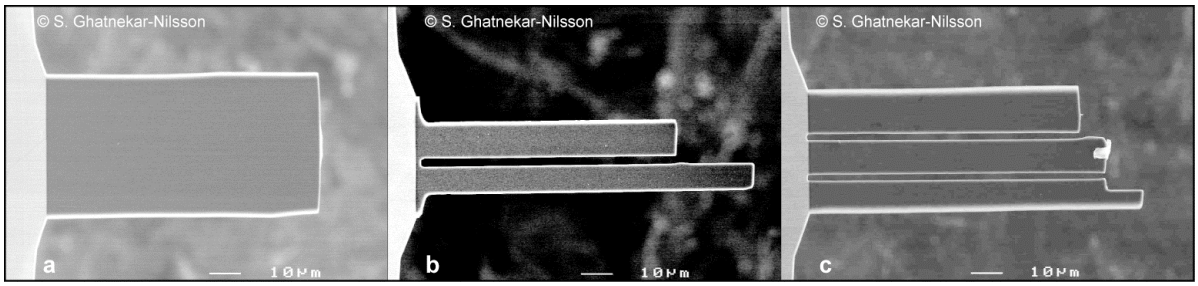

Figure 1. Scanning electron microscope images of focused ion beam machined cantilevers. (a) A shortened Si cantilever (l = 88µm). (b) An array of two Si cantilevers (l = 81µm and 106µm). (c) An array of three Si cantilevers (l = 87µm, 95µm and 107µm).

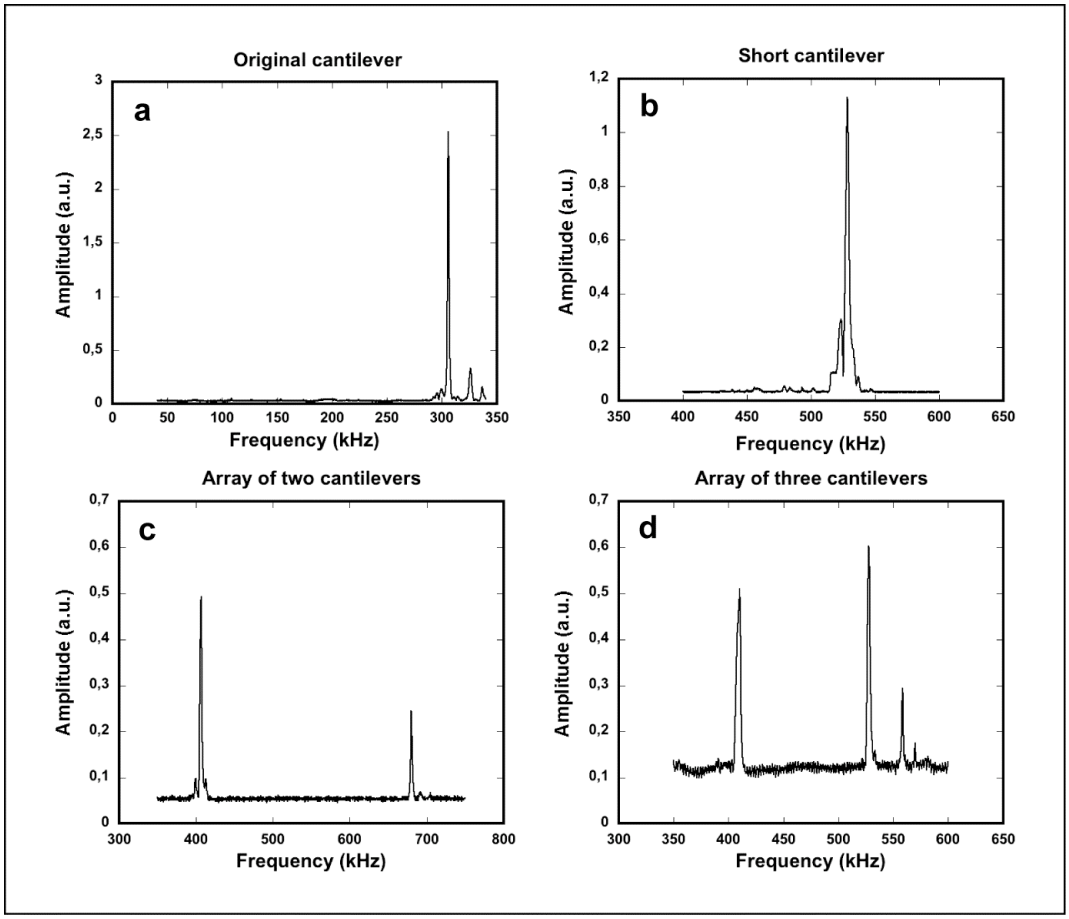

Figure 2. The graphs show resonance frequency spectra for (a) an original Si cantilever and (b-d) the FIB- machined Si cantilevers. (a) The frequency peak for an original Si cantilever is located at 306 kHz. (b) The shortened cantilever has its peak at 530 kHz. (c) The array of two cantilevers shows the resonance peaks at 406 kHz and at 680 kHz. (d) The array of three cantilevers has the frequency peaks at 410 kHz, 530 kHz and 560 kHz.