

Self-Actuated Piezoresistive 512-Cantilever Arrays for Large-Area Imaging and Manipulation

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Parallel operation of large Scanning Proximity Probes (SPP) arrays makes possible high rate imaging/measurement throughput. It can be achieved properly with arrays of individually driven and independently sensing cantilevers. Such operation has been realized by integration of each cantilever with a thermal bimorph (bimetal) actuator and piezoresistive readout. In order to enable fabrication of large, two-dimensional arrays and to ensure free approach of all cantilever to the scanned sample, vertical interconnection technology has been employed to lead the electrical signals to the back-side of the chip. Thus, vertical interconnection makes possible an integration of SPP array directly with the ASIC based driving electronics.

Arrays of up to $8 \times 64 = 512$ thermally driven, piezoresistive cantilevers with vertical interconnections are successfully fabricated¹ within the frames of 6th FP EU Project PRONANO (Figure 1). The probes are 300 μm long, 100 μm wide and 4 μm thick. All cantilevers are off-plane bent of about 50 μm and thus can freely approach the surface of a scanned sample²⁻³ and are integrated with sharp silicon tips⁴ for high-resolution imaging. The characterization of the cantilevers proves 0.1nm z-resolution, nW-actuation power per cantilever (in non-contact mode) and negligible electrical cross-talk between sensor and actuator. Figure 2 presents typical PRONANO result of (1160x160 μm) proximity image, recorded in one scan. The imaging is realized by overlapping of the single scanned fields, which allows reconstruction of the complete picture.

¹ Y. Sarov et al. *J. Vac. Sci. Technol. B*, **27** 3132 (2009).

² Y. Sarov, Tzv. Ivanov, A. Frank, I.W. Rangelow, *Appl. Phys. A* **92** (2008) 525

³ Y. Sarov, T. Ivanov, I. Rangelow, *Appl. Phys. A* (2010) DOI: 10.1007/s00339-010-6078-1

⁴ M. Woszczyzna et al. *J. Vac. Sci. Technol. B* **28** (2010) C6N13 (pg. 1-6).

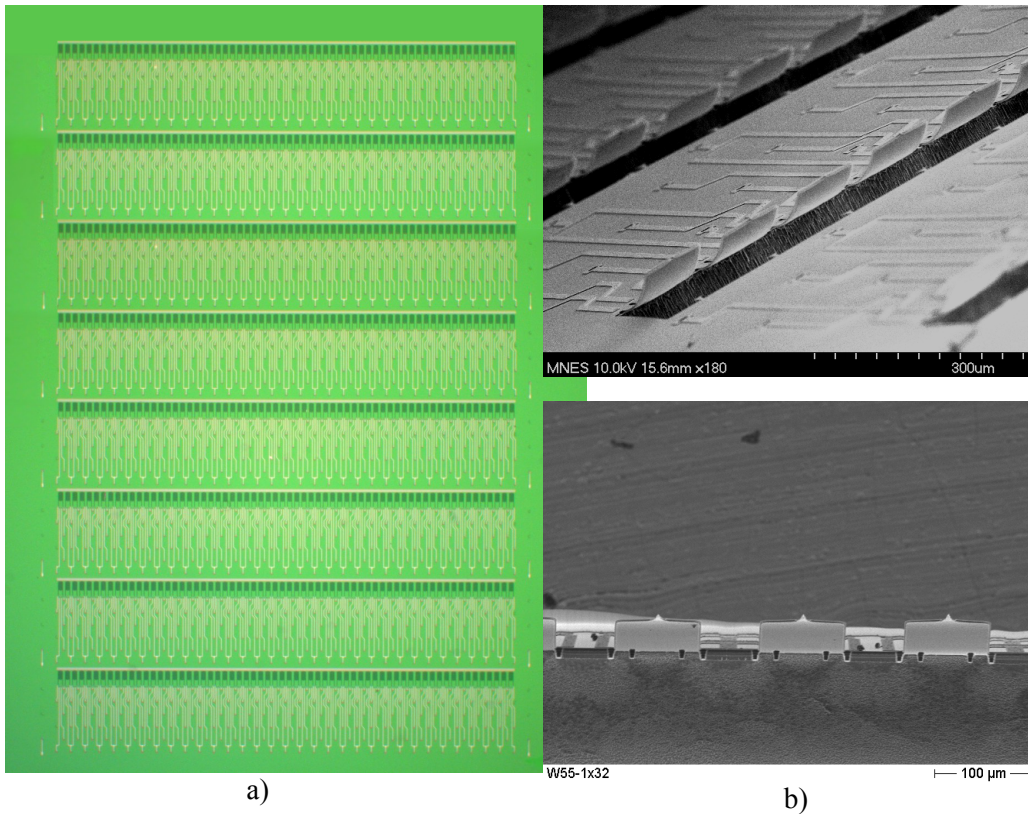


Figure 1: An array of $8 \times 64 = 512$ self-actuated piezoresistive cantilevers with vertical interconnections; a) optical image, b) SEM pictures shown details of array with pre-bended cantilevers with tip.

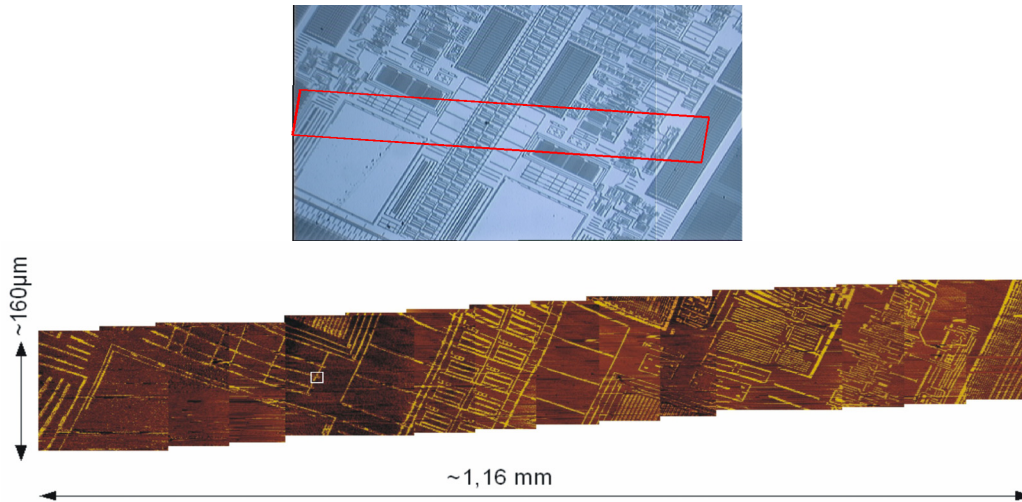


Figure 2: Optical view of imaged IC sample and PRONANO-AFM-image (dimensions of the area measured using PRONANO array is $1160 \times 160 \mu\text{m}$).