New technology for the read-out of arrays of micromechanical sensors for biomedical applications

Oscar Ahumada*, Nicolas F. Martinez*****, Priscila Kosaka[†], Javier Tamayo[†]. M. Calleja[†]

*MecWins R&D Division, c/ Santiago Grisolía 2, 28760 Tres Cantos (Spain)
[†]Instituto de Microelectronica de Madrid, CSIC, c/ Isaac Newton, 8, 28760 Tres Cantos (Spain)
oahumada@mecwins.com

In the last years, microcantilevers have been increasingly used as mechanical transducers of molecular recognition events[1 2 3 4]. The transduction signal of nanomechanical sensors is a nano-scale motion. This nanometric deformation arises from the intermolecular forces that are generated by molecular recognition interactions on the sensitized surface of a microcantilever. Main techniques for the readout of the nanomechanical response include the optical lever method, interferometry-based methods integrated optical waveguides and the use of piezoresistive cantilevers. The optical lever method is the most used due to the extreme accuracy and easy implementation for measuring cantilevers.

In this contribution we present new instrument, SCALA, based on the scanning of a laser beam across a surface (up to centimeters). Deflection of the reflected beam during the scanning is collected on a position sensitive detector (PSD). This allows the instruments to perform the read-out of arrays of nanomechanical systems without limitation in the geometry of the sample, high sensitivity and a spatial resolution of few micrometers. Simultaneously our technology provides a complete map of the resonant properties. The instrument is able to operate in vacuum, air and liquids.

Measurement of nanoscale deformations on surfaces of cm^2 are performed automatically, with minimal need of user intervention for optical alignment. To exploit the capability of the instrument for high thoughput biological and chemical sensing we have designed and fabricated a two-dimensional array of 128 cantilevers (Fig 1(a)). We measured the nanometer-scale bending of the 128 cantilevers (Fig. 1(b)), previously coated with a thin gold layer, induced by the adsorption and self-assembly on the gold surface of several self-assembled monolayers[5].
In addition, we applied the technique for analyzing the vibration mode shape of a variety of nanomechanical systems that range from microcantilevers (Fig. 1(c)) to coupled nanomechanical resonators[6]. The technique is simple, allows imaging in air, vacuum and liquids, and it is unique in providing synchronized information of the static and dynamic out-of-plane displacement of nanomechanical systems. Additionally, it can create 3-D images of any arbitrary object (Fig. 2).

Finally we use the environmental chamber of SCALA for label-free detection of nucleic acid and proteins based on surface stress variations induced by tuning the environmental conditions[7].

[1] P. S. Waggoner and H. G. Craighead, *Lab Chip* **2007**, 7, 1238.
[2] K. L. **Ekinci**, M. L. **Roukes**, *Rev. Sci. Instrum*. **2005**, 76, 061101.
[3] H. P. Lang, M. Hegner and C. Gerber, *Materials Today* **2005**, 8, 30.
[4] Li M, Tang HX, Roukes ML, *Nature Nanotechnology* **2007**, 2 114-120.
[5] N. F. Martínez, P. M. Kosaka, J. Tamayo, J. Ramírez, O. Ahumada, J. Mertens, T. D. Hien, C. V. Rijn, and M. Calleja Rev. Sci. Instrum. **2010**, 81, 125109
[6] P. M. Kosaka, J. Tamayo, E. Gil-Santos, J. Mertens, V. Pini, N. F. Martínez, O. Ahumada and M. Calleja *J. Appl. Phys.* In press
7 J. Mertens, C. Rogero, M. Calleja, J.M. Gago, C. Briones and J. Tamayo, *Nature Nanotechnology* **2008**, 3, 301.

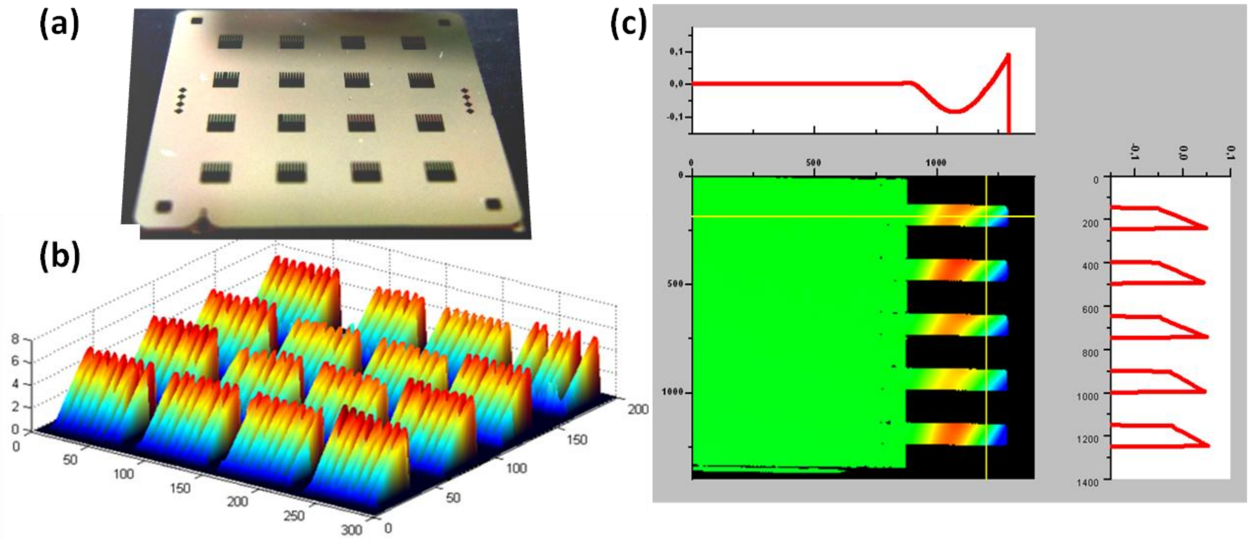

Fig. 1 *(a) Optical image of an 2D array of 128 microcantilevers arranged in 4x4 wells Each cantilever has 400 microns in length and 50 microns in width.(b) SCALA height image of the whole array.(c) SCALA vibration image of an array of 5 microcantilevers of the second vibration mode at 60 kHz.*

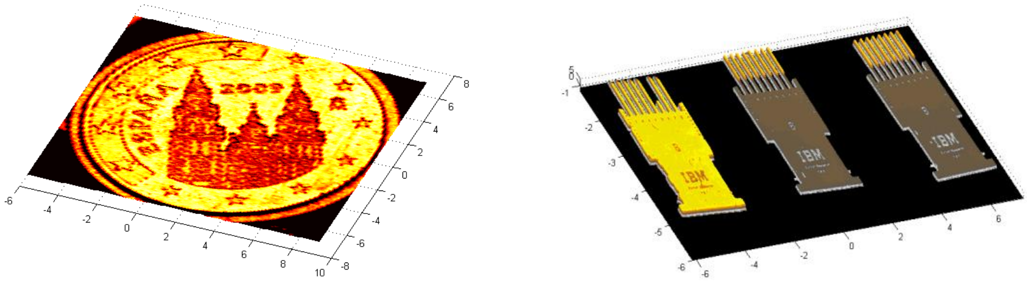

Fig. 2 *SCALA scanning of a one cent coin and three IBM cantilever arrays.*