Fully automated readout system for parallel characterization of microcantilever arrays using DVD-ROM pickup heads.

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Cantilever based sensors are promising and growing miniaturized sensing tools for bio-chemical applications [1]. The microcantilever is typically chemically or biologically functionalized to adapt for sensing specific analyte or biomolecules; several micromechanical-based sensing tools have been verified by their detection capabilities for DNA hybridization [2], protein, antibody and living cell [3].

In this paper we present a completely new and fully automated optical-based setup that is able to monitor simultaneously the resonance frequency (dynamic mode) and deflection (static mode) of different cantilevers over large sample and in a very short time. We have proved the capability to measure up to 4000 cantilevers profiles per second, without significant resolution loss. Furthermore the use of DVD-ROM pickup heads for optical readout leads to a very light, compact and high throughput optical device. Figure 1 shows the SU-8 cantilever array design employed in these experiments.

At present optical equipments used to measure the change in the resonance frequency and deflection of cantilevers are typically big and bulky because precise and delicate laser alignment is required. Present setup can perform just measurements on a single-chip, generating doubts on the reliability of the measurements, and furthermore dynamic and static modes have to be run separately.

In our system, up to 1300 cantilevers are placed onto a rotational platform fabricated with photolithography in SU-8 over a Pyrex glass, as shown in figure 2 [4]. The disk-like platform is spun at different angular velocities while the DVD-ROM pickup head, placed 1 mm below the glass disk, scans the cantilever tips and measure the deflection profiles using an astigmatism-based photodetector [5].

A 650 nm laser beam is emitted by a laser diode is focused on the cantilever tip with a 0.75 µm spot diameter. Cantilever gold coating allows the laser beam to be reflected back to the detection system, composed by a 4-quadrant photodetector.

Figure 3 shows the cantilever profiles acquired spinning the disk for three revolutions at 60 rpm. As shown in fig 3(c) we can obtain a complete cantilever profile composed by ca. 100 measurements points in less than a millisecond. The resolution of each measurement point is around 0.1 nm.

Another complete new feature of our system is that we are allowed to measure, spinning a low angular velocity, the resonance frequency of the cantilevers simply using a second (or more) DVD pickup head. Figure 4 shows measurement of resonance frequency performed using our system on a SU-8 cantilever coated with a thin gold layer. It has to be noticed that the high resolution of the optical pickup head allows measuring the resonance frequency even without external actuation. Our system thus can simultaneously monitor the bending due to environmental changes (temperature) as well as the shift in resonance frequency due, for example, to humidity absorption. The study of the response to external environmental changes would give important information about the behavior of such microstructures when moved in a real out-of-the lab environment, giving information about the reliability of these micromechanical sensors.

Our platform represents a completely novel and powerful tool for analyzing the response to environmental changes over an entire batch of microcantilevers, as well as a powerful tool for characterizing the uniformity of geometrical and elastic parameters over a wide sample of chips in a fast and accurate way.

[1] M. Álvarez, A. Calle, J. Tamayo, L. M. Lechuga, A. Abad, A. Montoya, Biosens. Bioelectron. 18, 649 (2003)
[2] J. Fritz, M. K. Baller, H. P. Lang, H. Rothuizen, P. Vettiger, E. Meyer, H.-J. Güntherodt, Ch. Gerber, and J. K. Gimzewski, Science 288, 316 (2000)
[3] J. W. Ndieyira, M. Watari, A. D. Barrera, D. Zhou, M. Vogtli, M. Batchelor, M. A. Cooper, T. Strunz, M. A. Horton, C. Abell, T. Rayment, G. Aeppli, R. A. McKendry, Nature Nanotech. 3, 691-696 (2008)
[4] F. G. Bosco, E.-T. Hwu, S. Keller, A. Greve, A. Boisen, Microel. Engineering 87, 708-711 (2010)
[5] E. T. Hwu, K. Y. Huang, S. K. Hung, and I. S. Hwang, Jpn. J. Appl. Phys. 45, 2368 (2005)

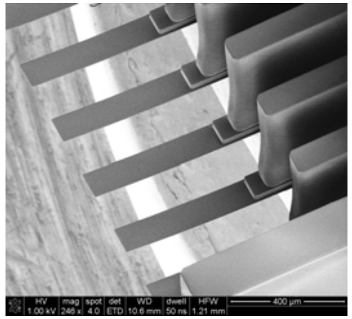

Figure 1. SEM picture of the array of 10 microcantilever fabricated in polymer SU-8. The bottom surface is coated with 20 nm of gold. Dimensions of the cantilevers are 100 µm x 500 µm x 5.2 µm.

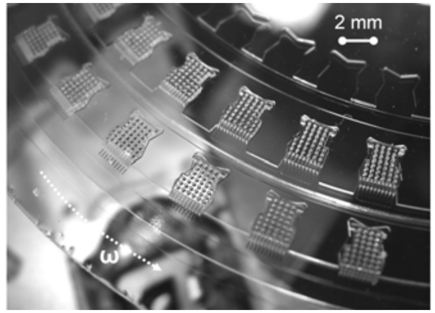

Figure 2. Picture of our 4 inch glass rotating platform where up to 130 SU-8 cantilever arrays chips can be clamped. The clamping structure is fabricated with photolithographic process.

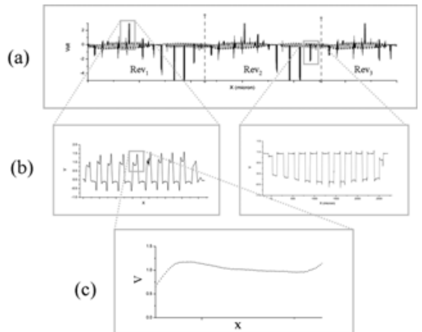

Figure 3. (a) 120 Cantilever profiles acquired spinning the disk for 3 revolutions at 60 rpm. (b) Different chips show positive (left) and negative (right) initial bending. (c) Single profile is composed by ca. 100 points

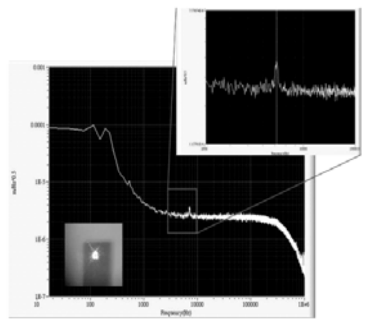

Figure 4. Resonance frequency measurement at 6.671 KHz of gold coated SU-8 cantilever performed with our DVD-ROM based system. Measurements are performed without external actuation.