Self aligned cantilever positioning for on-substrate measurements using commercial DVD optical pickup head

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Cantilever based sensors are promising miniaturized sensing tools for bio-chemical applications [1]. However, at present the optical equipment used to sense the change in the resonant frequency due to the selective binding of biomolecules to the cantilever surface is typically big and bulky because precise and delicate laser alignment is required. Here, we present a novel approach to measure the change of resonant frequency of cantilevers by using a light, compact, portable and high throughput optical device.

The optical readout of cantilever-based sensors was re-designed and developed combining the technology of commercial DVD-ROM readers [2] with a Pyrex-SU-8 holding substrate structured with UV-lithography processes. In traditional approaches a single chip is mounted on a holder, precisely aligned to the laser beam, and the cantilever thermal noise is measured through the oscillating position of the laser spot onto a photodetector.

In our system cantilever chips are clamped on a predefined holder while the DVD-ROM reader is placed 1 mm below the Pyrex substrate. The laser beam is collimated and focused on cantilevers with a 0.6 µm spot diameter. The reflected light is then recorded using the standard 4-quadrant DVD photodetector. The system is schematically illustrated in Fig.1.

One of the main challenges is the microfabrication of efficient holding structures that allow precise chip immobilization and cantilever alignment over a Pyrex aperture for the bottom-up laser reading.

Therefore, several footprint shapes were fabricated in order to optimize the holding properties for different cantilever chips fabricated under different processes: clamping of SU-8 [4], Silicon and TOPAS [5] cantilever-based chips was proven.

The cantilever suspending configuration was obtained spin-coating two layers of SU-8 on the transparent Pyrex wafer (n=1.47) with thicknesses of 50 µm and 300 µm, respectively. In Fig. 2 are shown gold coated SU-8 cantilevers suspended over such a 50 µm deep window.

We have observed that the substrate chip holding efficiency is highly increased moving from the traditional holder structure, where the body chip is encapsulated into a square footprint (edge-edge clamping), to configurations where the chip corners are clamped by the footprint walls (corner-edge clamping) or where the chip sides are clamped by concave footprint structures (edge-corner clamping) (Fig. 3).

These geometries allow better immobilization of the SU-8 chips that show intrinsic fluctuations of the dimensions due to the photolithographic process (up to 40 µm). SU-8 corners are in fact soft enough to be slightly deformed to adapt chips fabricated with different resolutions to precisely fit in the same footprint.

In Fig. 4 is shown typical thermal noise measurements of Au coated SU-8 cantilevers having length of 500 µm, width of 100 µm and thickness of 5.5 µm measured by using a commercial DVD pickup head.

The measurement signal from the preamplifier is recorded by a PC through a data acquisition card (DAQ) which has a bandwidth of 20 MHz and a resolution of 14-Bit. After the FFT data processing, the resonance frequencies of the cantilevers can be shown in thermal noise spectra in frequency domain [3].

The integration of the DVD reader with the on-substrate holding approach leads to a high throughput flexible platform with easy auto-alignment and replacement of the 8-cantilevers chips. With this new on-substrate approach tens of chips can be placed on the Pyrex-SU-8 wafer and be read sequentially.

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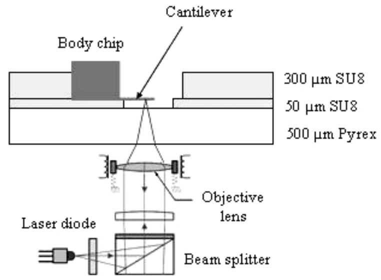

Figure 1. Laser path scheme: the laser beam passes through the Pyrex window before being focused on the cantilever. A perfectly focused beam has a spot size of ca. 0.6 µm.

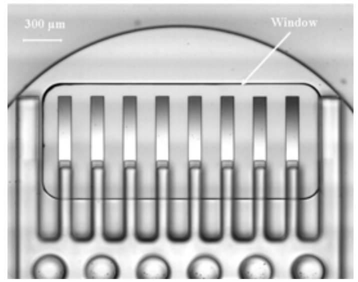

Figure 2. Eight-cantilevers chip fabricated in SU-8. The 500 µm long and 100 µm wide gold coated cantilevers are suspended over the 50 µm Pyrex window.

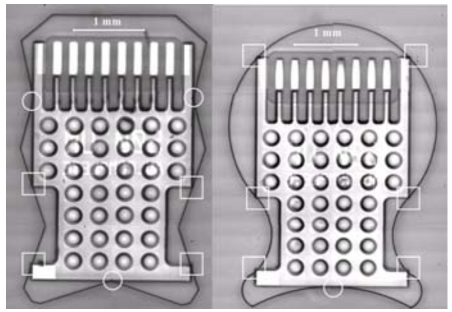

Figure 3. Two footprint configurations for SU-8 chips with high immobilization efficiency. They integrate both edge-corner (round markers) and corner-edge (square markers) clamping points.

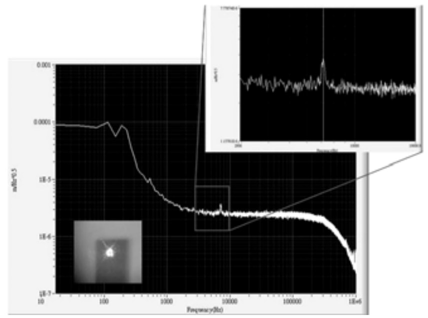

Figure 4. Thermal noise measurement using DVD pickup head. The focal point on the cantilever is ca. 583 nm (FWHM). The fundamental resonance frequency of the cantilever is 7.15 kHz.