Nanoelectromechanical mass sensor fabricated by nanoimprint lithography

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Nanoimprint lithography (NIL) is a low cost, high throughput patterning technique with high resolution. With this technique, miniaturized sensor with high sensitivity could be produced for the requirement of many different applications. Here we introduce the NIL based fabrication and performance characterization of a novel mass sensor which is based on laterally deflectable cantilever array structures. The mass sensor could be read out by both optical and electrical methods.

The structure of our mass sensor is a laterally deflectable double-finger interdigitated cantilever array [**Fig. 1**], which is made on SiO_2/Si substrate covered by a thin metal layer. The pattern of the device is fabricated by both hot embossing lithography and UV nanoimprint lithography. Using the pattern as an etching mask, freestanding cantilevers are obtained by isotropic and anisotropic reactive ion etching. In the final step, a metal layer is evaporated onto the structures. When a bias voltage is applied to the device, the cantilevers will bend to each other due to the electrostatic force.

When an AC voltage with variable frequency is applied to the device, the oscillating behavior of the cantilevers array is detected with a photodiode by studying the intensity of a diffraction spot. From these investigations the resonance frequency of cantilevers array could be determined. For a structure that the cantilevers were 15 μm long, 200 nm wide and apart from each other with 550 nm, the resonance frequency was determined to be 1.15 MHz. This is in good agreement with theoretical calculations. We also detected the resonance frequency by electrical measurements based upon changes in the capacitive signal. The resonance frequency obtained from these electrical measurements correlates very well with the results obtained by the optical diffraction technique.

In addition, experiments to investigate the frequency shift due to mass loading onto the cantilever arrays have been performed. The target molecules used here were thiol ($CH_3(CH_2)_{11}SH$) which adsorbed onto the Au-coated cantilevers. This extra mass from the adsorbed thiol induced resonance frequency shift of 25 kHz [**Fig. 2**] [**Fig. 3**], which corresponds to a massloading of $6x10^{-15}$ g. Further development of the fabrication process and the signal readout are still underway.

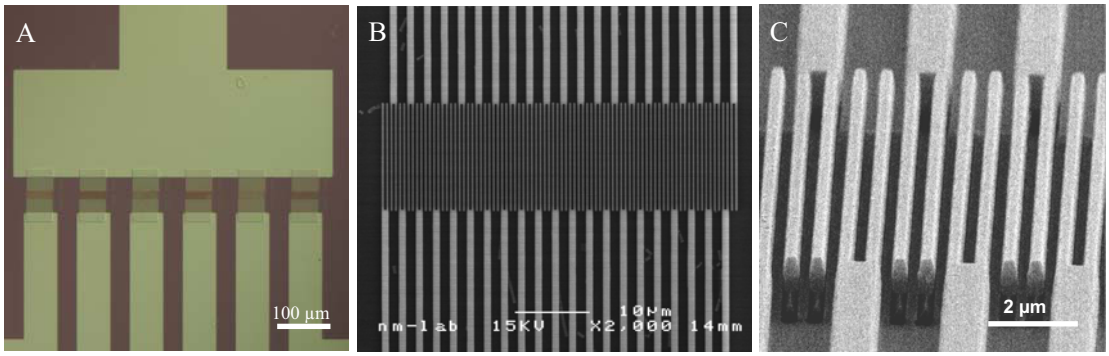

Fig. 1 (A) An optical microscope image of the device pattern;
(B) SEM image of a cantilever array; (C) Side view of the cantilevers.

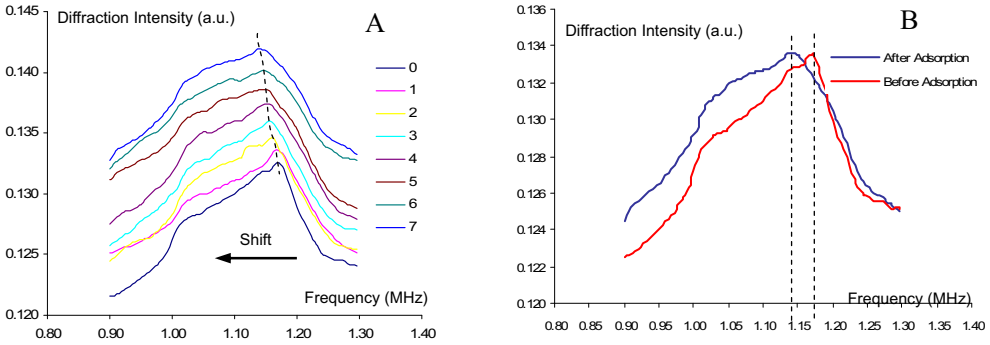

Fig. 2 (A) The resonance frequency shift gradually because of mass loading onto the cantilevers; (B) the resonance frequencies of the device before and after adsorption of thiols.

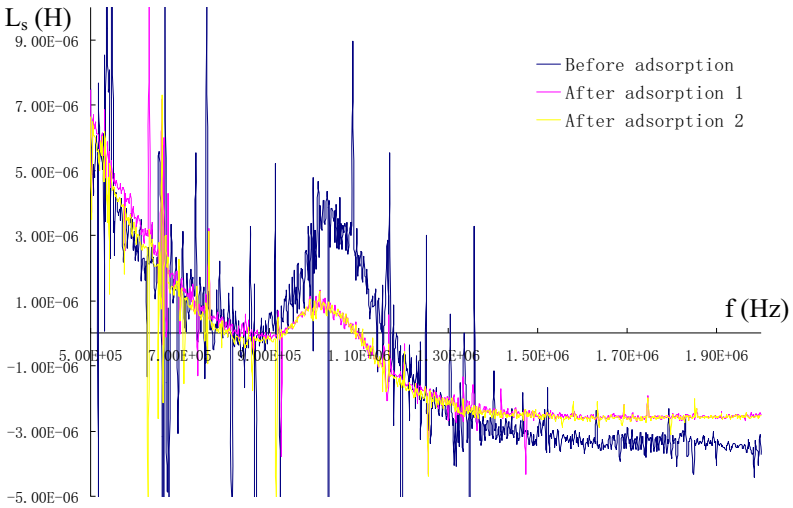

Fig. 3 The electrical readout of the resonance frequency: before adsorption, after adsorption and repeated adsorption.