Micro-weighing based Biosensor with Using an Adaptive Interferometry

Efimov Timofey, graduate student of Far Eastern Federal University, Vladivostok, Russia
Email: efimov@iacp.dvo.ru

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Introduction

Micromechanical oscillator operating in a dynamic mode

Some of the most common biosensors

- **Quartz resonators**
- **Surface plasmon resonance biosensors**
- **Whispering gallery mode resonators**
- **Micro- and nanoelectromechanical systems**

Most types of biosensors assume the presence of some sensor area, the minimum size of which is limited and usually amounts to tens or hundreds of microns. Reducing the size of the sensor leads to a decrease in its sensitivity.

Biosensor built using a micromechanical oscillator

The sensitivity increases with decreasing sensor size

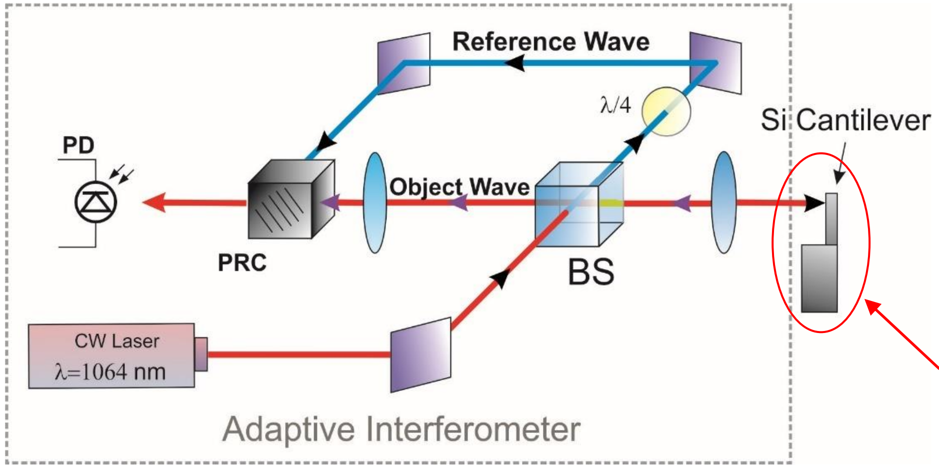
Resonant microbalance mass measurement

The frequency of natural oscillations of the oscillator is inversely proportional to the change in the mass of objects adsorbed on its surface.

Sensors based on resonant microbalance are able to measure the mass change of objects attached to the cantilever with an accuracy of several attograms.

Experimental Setup

Adaptive Holographic Interferometer



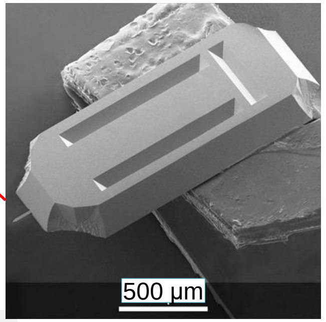


Figure 1. scheme of the experimental setup. BS – beam splitter; PRC – photorefractive crystal; PD – photodetector; λ/4 – quarter wave plate.

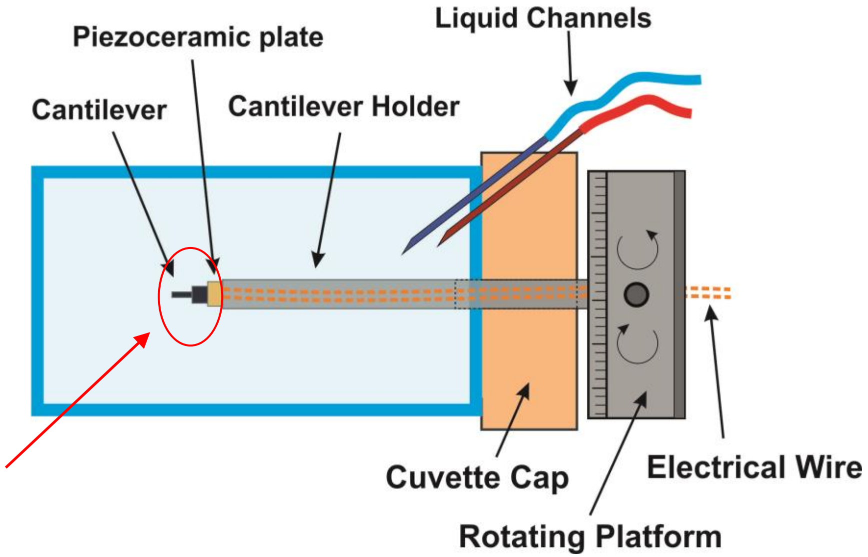


Figure 2. Liquid cell with a placed cantilever.

For experimental measuring of the resonant frequencies of cantilevers we used an adaptive holographic interferometer based on two-wave interaction of waves in a photorefractive crystal CdTe:V. The cantilever was placed in a flow cell and installed in the object beam of the interferometer.

To excite natural oscillations was used piezoceramic plate.

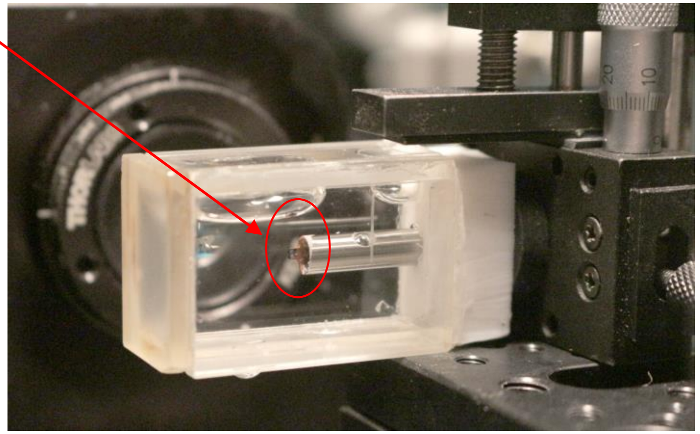


Figure 3. Photo of Liquid cell with a placed cantilever.

Recoded Signal

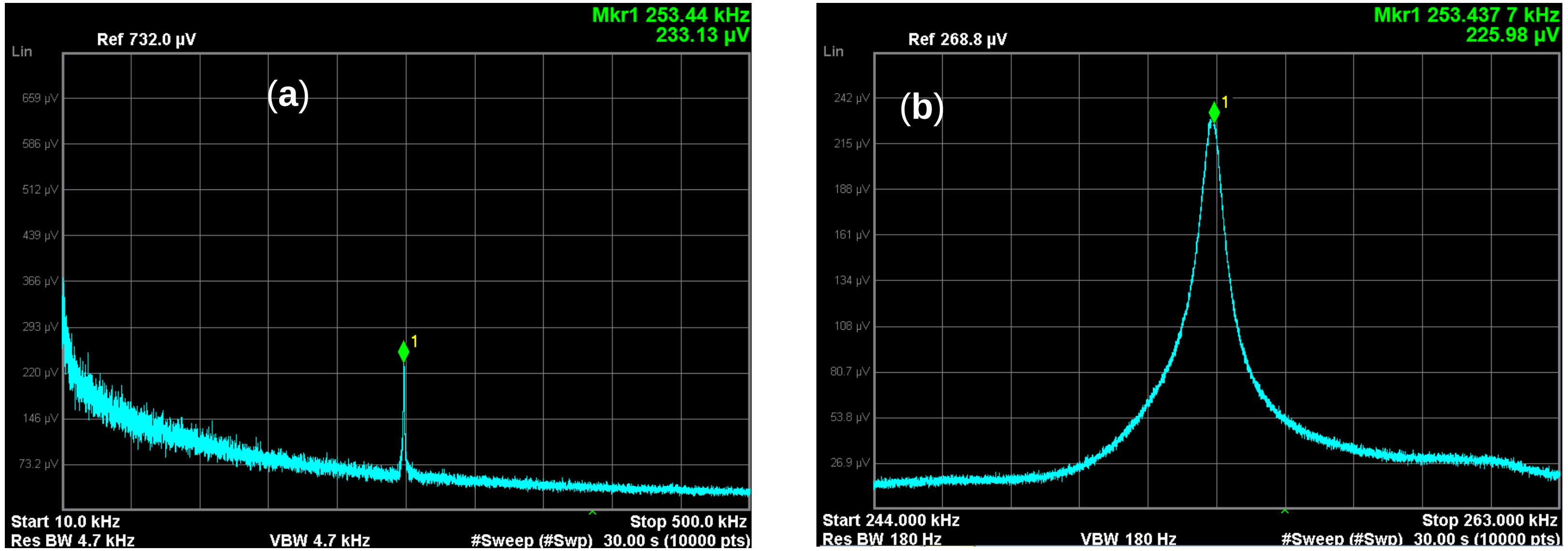


Figure 4. Spectrum recorded by an electrical signal spectrum analyzer: (**a**) Spectrum in a wide frequency range with a well-defined resonant peak; (**b**) Resonance peak corresponding to the natural frequency of the cantilever.

The cantilever was coated with a thin gold film 20 nm thick by electron beam evaporation. Performance of the biosensor testing in detecting BSA molecules (Bovine Serum Albumin). The gold layer was activated with a solution of NHS-EDC.

The frequency of natural oscillations of the oscillator is inversely proportional to the change in the mass of objects adsorbed on its surface.

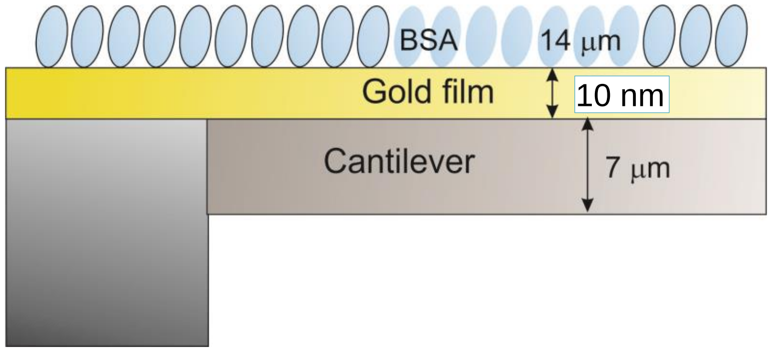


Figure 5. Cantilever coated with 10 nm gold film with attached BSA molecules.

Results

The oscillation frequency of the cantilever was measured before and after transferring it to the liquid cell. The frequency decreased from **253442**±23 to **98561**±41 kHz

BSA solution with a concentration of 10 mg/ml was introduced into the cuvette. The attachment of BSA molecules resulted in a shift in the resonant frequency of the cantilever by **2049 Hz**. Taking into account the error in determining the resonant frequency, the minimum detectable concentration of BSA in this experiment was **0.2 mg/ml**.

The results show that the biosensor is capable of detecting the mass and concentration of absorbed BSA molecules in a water solution. The attachment of BSA molecules is performed by activating the surface of the silicon cantilever with a solution of NHS-EDC. The study indicates that adaptive interferometry can be used to detect the vibration of micromechanical sensors and shows potential prospects for building biosensors based on them.

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Thank you for attention!

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