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Multiplexed SOI Ring Resonators for Biosensing Applications

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1. Introduction

Refractive index optical biosensors provide a label free solution for molecule sensing applications. SOI technology is used because the high refractive index contrast confines the light within the waveguide and its fabrication process is compatible with the mature CMOS technology. The sensing principle is to measure the shift of the resonance wavelength as the surrounding refractive index changes due to the adsorption of particles on the surface of the sensor.

2. Experimental Setup

The SOI chips used for the experiments had 10 ring resonators coupled to the same waveguide in a series configuration. This way, each ring could be functionalized to detect a different biomolecule while only having to couple the light in and out of one access waveguide [1]. In order to distinguish which resonance dip belongs to which ring from the output spectrum, one by one, each ring was thermally modulated by an AC source. The small sinusoidal variation in the resonance frequency due to the thermo optical effect was detected with a lock-in amplifier [2]. A laser was continuously swept from 1547 nm to 1552 nm with a 4 pm resolution and coupled to the waveguide via grating couplers. A power meter was applied to track the shift of the resonance frequency in real time. The chip was stabilized at 25 °C and a syringe pump was used to deliver the analyte at a flow rate of 20 μL/min using a microfluidic flow cell.

3. Results

First, the sensitivity was measured by introducing different concentrations of NaCl in DI water, obtaining a sensitivity of 2.88×10^{-4} RIU for each ring. This result confirms the correct multiplexing design.

The next experiment was to introduce a buffer solution, PBS, for 2 hours to create a baseline, followed by the injection of a protein solution in PBS (1 mg/mL), and a final step of PBS to wash off any redundant protein that has not bind to the surface.

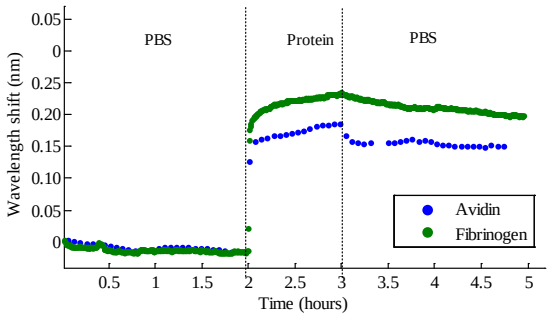

Figure 1 Sensorgram for the injection of proteins

From the sensorgram we can see that the resonance wavelength shifts at a rate that could be coarsely approximated as logarithmic when the protein is introduced to the sensor as it unspecific binds to the surface. Then, it saturates when the surface has been completely covered. The binding curve confirms that we were sensing the adsorption of molecules and not a bulk refractive index change.

The maximum wavelength shift in this experiment for avidin is 200 pm and for fibrinogen is 251 pm. The experiments were repeated obtaining similar curves, with a mean shift of 181 pm for avidin and 256 pm for fibrinogen.

The flow rate used during the final wash off procedure was low enough that it does not break the unspecific binding between the surface and the protein in any of the experiments. Possibly, the high isoelectric point of the proteins binds them to the surface and therefore, there is no return to the baseline level.

As summary, we have shown that this type of sensors is suitable for label-free real-time detection of molecule adsorption.

References

[1] M. Jäger, et al, *Optical Sensors*, St4B.3 (2013)

[2] P. Lützow, et al, *Optics Express*, vol. 19, pp. 13277 (2011)