TOWARDS A SILICON DUAL POLARIZATION RING RESONATOR SENSOR FOR MULTIPLEXED AND LABEL-FREE STRUCTURAL ANALYSIS OF MOLECULAR INTERACTIONS

T. Claes [a,b*], D. Vermeulen [a,b], P. De Heyn [a,b], K. De Vos [a,b], G. Roelkens [a,b], D. Van Thourhout [a,b], P. Bienstman [a,b]

[a] *Photonics Research Group, Department of Information Technology, Ghent University—IMEC, Sint-Pietersnieuwstraat 41, 9000 Ghent, Belgium*
[b] *Center for Nano- and Biophotonics (NB-Photonics), Ghent University, Ghent, Belgium*

tom.claes@intec.ugent.be

Label-free evanescent wave biosensors, such as surface plasmon resonance and ring resonator sensors, are often employed to study biomolecular interactions in real-time with only little sample preparation. By monitoring the phase change of a single optical mode, they measure the combined change of the refractive index and thickness of a biomolecular layer, which can be linked to a molecular concentration. Nevertheless, a disentanglement of these parameters would yield extra information on the molecular structure, such as DNA-orientation and protein conformation, which is of great interest in the study of biomolecular interactions and which has already proven to play an important role in several cancers and in Alzheimer's disease.

Using two optical modes that interact differently with the biomolecules allows to measure both the refractive index and thickness of the biomolecular layer. This is the working principle behind the commercial Dual Polarization Interferometer sensor from Farfield Scientific Ltd. However, this sensor does not allow highly multiplexed sensing, heavily limiting its throughput. Therefore, we propose a silicon ring resonator sensor that simultaneously and independently senses biomolecular interactions with two polarizations in a similar way, but that additionally is compatible with a high degree of multiplexing and allows low-cost wafer-scale fabrication.

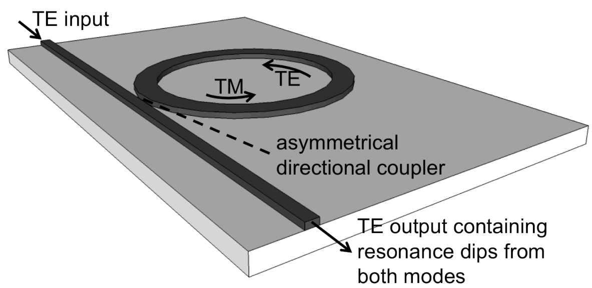

Figure 1 The proposed dual polarization ring resonator has a single access waveguide of which the quasi-TE mode is coupled to both the quasi-TE and quasi-TM modes of the ring resonator, using a cross-polarization directional coupler between two waveguides with different widths.

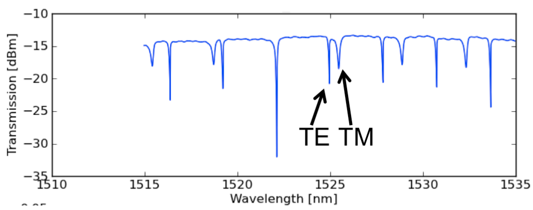

Figure 2 The measured transmission spectrum of our silicon dual polarization ring resonator sensor exhibits resonance dips for both its quasi-TE and quasi-TM mode. As both modes have a very different field distribution, their resonance wavelengths will shift differently for the same biomolecular interaction, which allows to differentiate between the layer refractive index and thickness.

We calculated the feasible performance of this silicon dual polarization ring resonator sensor and concluded that its accuracy can be sufficient to detect conformational changes of proteins, indicating its applicability. We designed and fabricated a ring resonator that employs a cross-polarization directional coupler to simultaneously excite both polarizations and allows easy interrogation with grating couplers (***Figure 1***). The sensor was made with mass fabrication compatible optical lithography and its transmission exhibited clearly visible resonance dips for both modes (***Figure 2***). We moreover performed an experiment to proof the concept of this dual polarization ring resonator sensor by measuring the refractive index and thickness of thin layers.

Our results demonstrate the novel concept of a dual polarization silicon ring resonator sensor that simultaneously senses the refractive index and thickness of thin layers. It offers the opportunity to also measure structural changes during biomolecular interactions, possibly adding important functionality to the highly multiplexed platform of label-free silicon ring resonator sensors.