

Systemic comparison of dielectric and plasmonic biosensors on a silicon photonics platform

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Plasmonic and dielectric based waveguides are widely used for biosensing applications. However, the use of different sensing architectures and platforms hinders the fair comparison of their respective figures of merit. In this paper, plasmonic and dielectric-based photonic waveguide biosensors are compared in terms of attainable limit of detection, using in both cases a coherent-readout interferometric architecture and the same commercial manufacturing platform.

Keywords—*Plasmonic biosensor, photonic biosensor, limit of detection, Mach-Zehnder interferometer, coherent readout.*

I. INTRODUCTION

Optical biosensors can detect the presence of a specific biomarker into a sample. To achieve this goal, a physical transducer translates first the biomolecular recognition into a refractive index variation and then into a conveniently measurable quantity, such as optical power or resonance wavelength. Many research groups and companies support plasmonic waveguides as the most suitable solution for biosensing applications as they offer better miniaturization and higher sensitivity values than dielectric photonic waveguides. However, the high propagation losses of plasmonic waveguides stemming from their metallic nature hampers the detection of very small concentrations of analyte, thereby degrading the attainable limit of detection. Although plasmonic biosensors based on Kretschmann configuration are the most widely commercially used, the integration of a plasmonic waveguide with dielectric interferometric architectures allows for simpler miniaturized systems and low-cost mass production [1]. Moreover, conventional limitations arising from the sinusoidal nature of interferometric sensors such as sensitivity fading and phase ambiguity can be overcome by using a coherent detection scheme built on the principles of optical coherent communications [2].

Accordingly, it is interesting to compare the best performances that can be obtained, on the same manufacturing platform, by using plasmonic and dielectric sensing waveguides on a coherent-readout based Mach-Zehnder interferometer (MZI) architecture. In order to perform a comprehensive analysis, a systemic model is employed to obtain detection limit values for each case.

II. SYSTEMIC ANALYSIS OF THE SENSING ARCHITECTURE

In this work we compare the performance of the coherent phase detection MZI sensing system shown in Fig. 1 when the sensing arm consists of either a dielectric or a plasmonic waveguide. Since system noise must also be taken into account, the figure of merit used to compare both technologies is the detection limit, which indicates the minimum amount of analyte

the system can detect [3]. Considering shot and thermal noise from the amplifier stage and neglecting quantization noise, it is concluded from this analysis that: i) losses, in both the sensing and reference arms, should be minimized; ii) a 50% power splitter should be used and iii) the system based on dielectric waveguides allows detecting refractive index variation approximately 10 times lower and analyte layer variations approximately 75 times smaller. However, the price to be paid is the required very long sensing arm lengths (~ 10 mm) compared to plasmonic waveguide based sensors (~ 160 μm).

III. CONCLUSION

Plasmonic waveguides are typically regarded in biosensing as exhibiting higher sensitivity values than dielectric waveguides and increasing compactness. However, due to their higher losses, the achieved limit of detection is worse when integrated in a Mach-Zehnder architecture with a coherent readout system that allows simple and unambiguous detection.

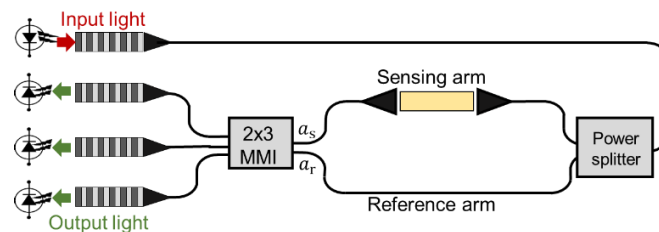


Fig. 1. Schematic of an integrated plasmonic waveguide in a dielectric MZI sensing system with coherent readout. A dielectric waveguide is used in the sensing arm for the case of dielectric based biosensor.

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