Design and Simulation of MZI Biosensor

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Abstract

The use of biosensors that are portable, user-friendly, and possess high sensitivity for rapid diagnosis could provide notable benefits compared to existing analytical approaches. Among various biosensor technologies, evanescent wave-based silicon photonic biosensors have emerged as the most favorable option for creating truly point-of-care devices.

We have design the single mode waveguide based MZI biosensor by varying different geometry parameters. The results shows how the changing in geometry of waveguide or arm length can change the FSR of the MZI biosensor. These calculation can help to optimize the design of waveguide for biosensing technologies.

Introduction

Medical Diagnostic have become critical in healthcare by providing early detection and timely care.

Inadequate **point-of-care** facilities do not address the need of majority of patients. The label-based approach delays results, adds to costs due to specialized reagent requirements, and needs complex micro-evaluations using large, automated analyzers.

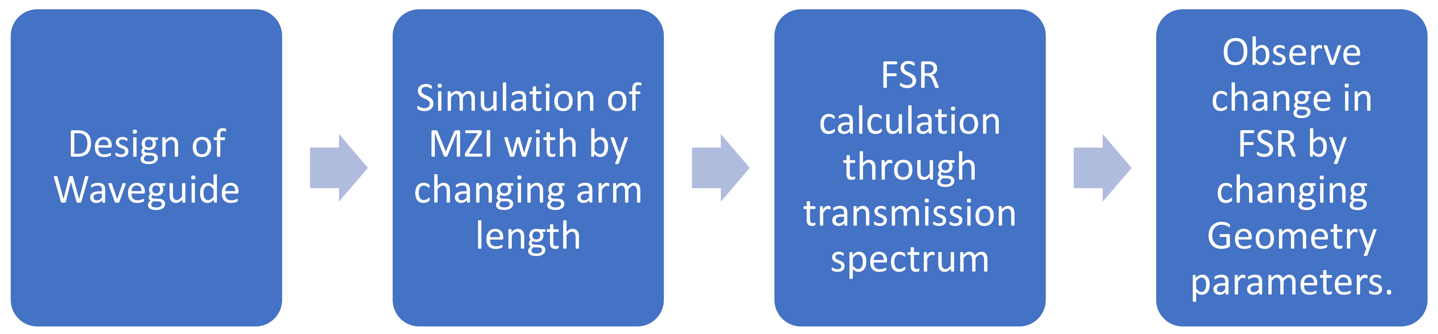
A highly sensitive, fast and economic techniques of analysis are desired for point-of-care (POC) diagnostic applications to improve access to cost-effective healthcare technologies.

The development of optical biosensors is one of the most promising approaches to satisfy the growing demand for effective medical diagnostic technologies. Silicon Photonics has high potential to promote sustainability in healthcare by reducing the environmental impact of medical waste and improving patient outcomes.


Figure 1. Traditional Laboratory Testing


Figure 2. Point of Care Testing

Methods and Materials



The overall proposed experimental setup is shown above in Figure. First, we have simulated the waveguide with different geometry parameters (i.e. by changing its width). Then, we simulated the MZI and calculated the free spectral range by varying its length.

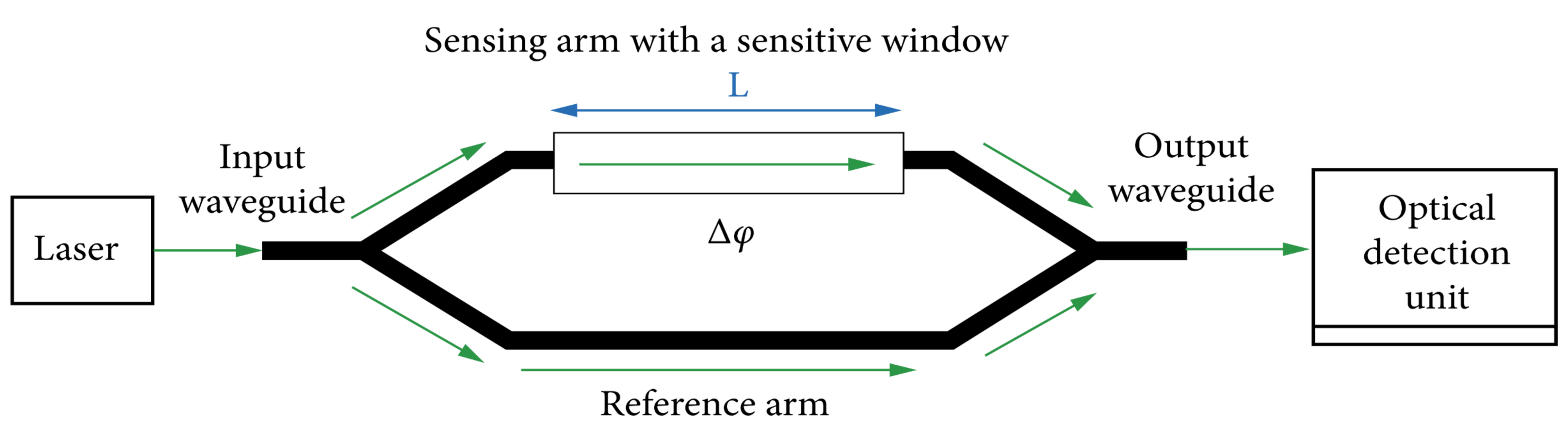


Figure 3. MZI Biosensor based on SOI Waveguide

Results

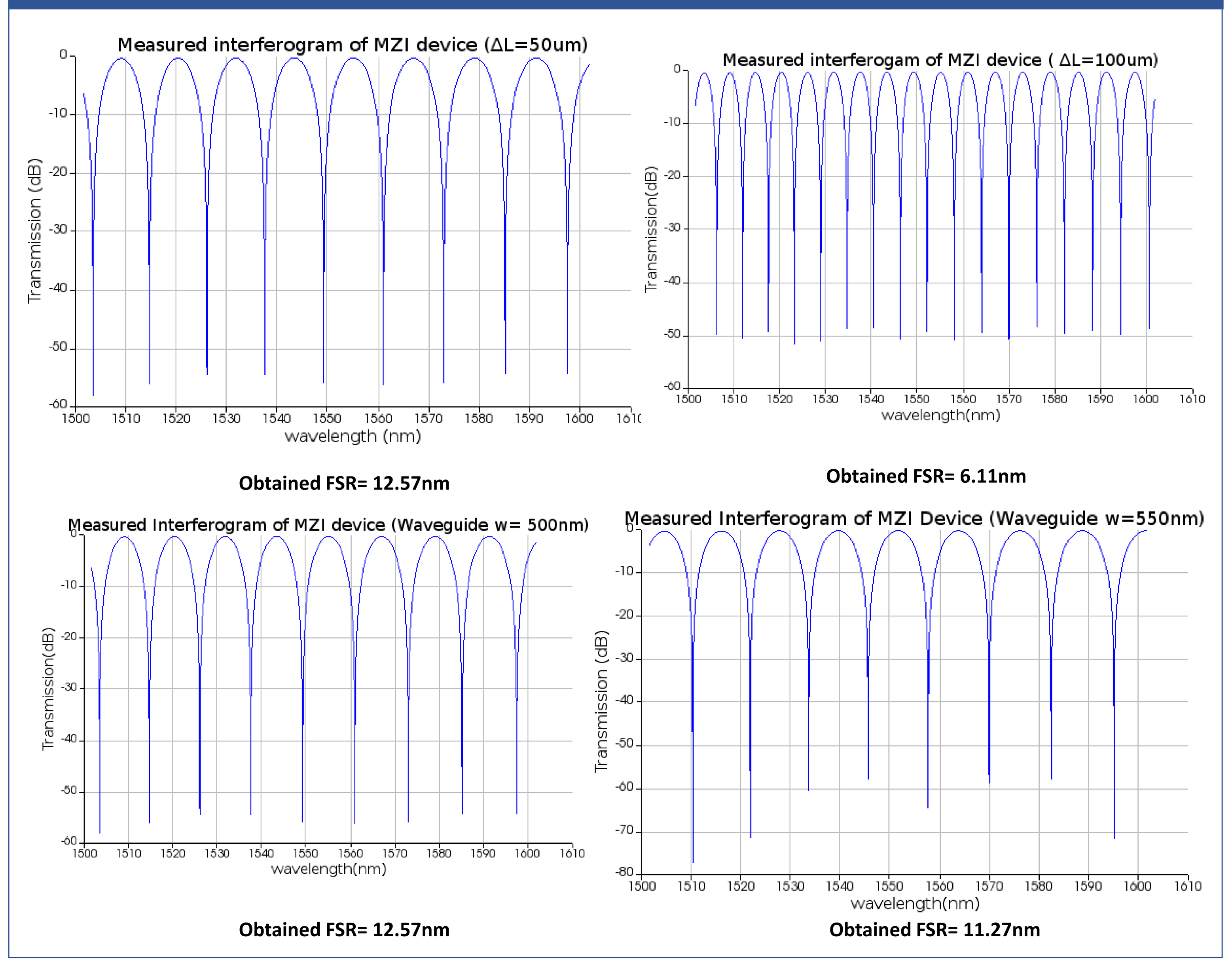
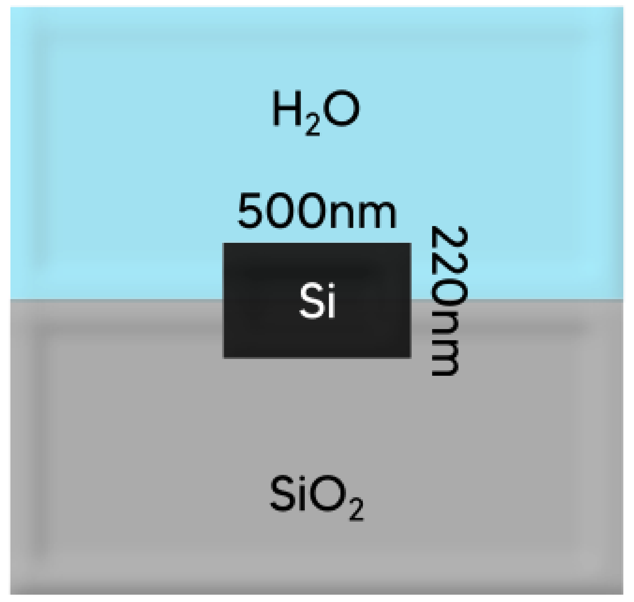


Figure 4. Transmission Spectrum of MZI Biosensor



Si SOI Waveguide

Discussion

- Figure 4 shows that the changing arm length and changing width of waveguide, changes its free spectral range.
- For arm length difference 50um, the obtained FSR is 12.57 nm and for 100um the obtained FSR is 6.11 nm.
- Similarly with waveguide width 500nm, FSR obtained is 12.57 nm and with 550nm FSR is 11.27 nm.
- We can optimize our device for biomolecule by changing its geometry parameter.
- These FDTD simulations of the MZI showed that the device has a high sensitivity, with a small change in refractive index leading to a significant change in the interference pattern.
- This high sensitivity makes the MZI ideal for use in lab-on-chip applications, such as biosensing and chemical sensing, where small changes in the refractive index of the sensing material need to be accurately measured.

Conclusions

- Photonics research has significant potential when it comes to practical applications.
- Silicon photonics-based biosensors offer a highly sensitive and sustainable alternative to traditional biosensing technologies.
- The use of MZI-based biosensors, in particular, offers several advantages, such as a high sensitivity to small changes in the refractive index and the ability to operate over a wide range of wavelengths.
- By changing the waveguide geometry and arm length, it is possible to achieve a high level of accuracy and precision in the detection of target molecules.

References

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