Design and Simulation of Mach-Zehnder Interferometer for Lab-on-Chip Applications

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1 Introduction

Medical diagnostics play an essential role in disease diagnosis and its early detection in the healthcare industry. [1] Medical waste generated from these procedures is highly hazardous and may cause adverse health effects. [2] But, thanks to silicon photonics-based biosensors that have revolutionized the medical diagnostic field for different purposes i.e. Point-of-Care applications and environmental monitoring. [3] Silicon Photonics has high potential to promote sustainability in healthcare by reducing the environmental impact of medical waste and improving patient outcomes. It can help to develop non-invasive sensors based on the principle of optics that can reduce medical waste. The goal of our project is the design and simulation of MZI-based biosensors for Lab-on-Chip applications with high sensitivity and less waveguide loss. So that the smaller change in refractive index due to the presence of the target molecule could be detected.

2 Methods and Results:

Our project investigates the free spectral range of different MZI-based biosensors. The 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. First, the waveguide with core silicon and cladding made up of has been simulated with varying geometry to check which waveguide has less confinement loss operating on telecom wavelength. Then, the waveguide with less confinement was used to simulate the Mach-Zehnder Interferometer with different arm lengths to check the Free Spectral Range of the biosensor that determines its sensitivity.

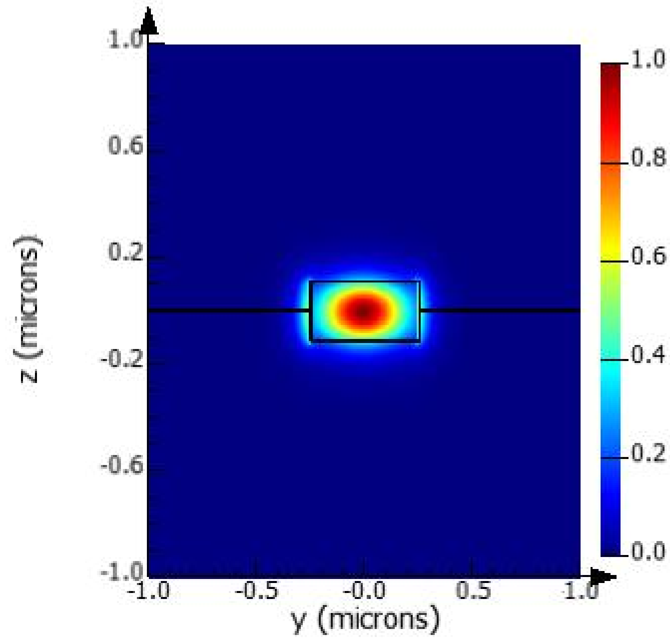

Figure 1: Illustration of electric field intensity distributions of the TE mode in a 220 × 500 nm silicon waveguide at Telecom wavelengths. The Si waveguide core (neff = 3.47) is buried in half water and half SiO_2 layers 4um each.

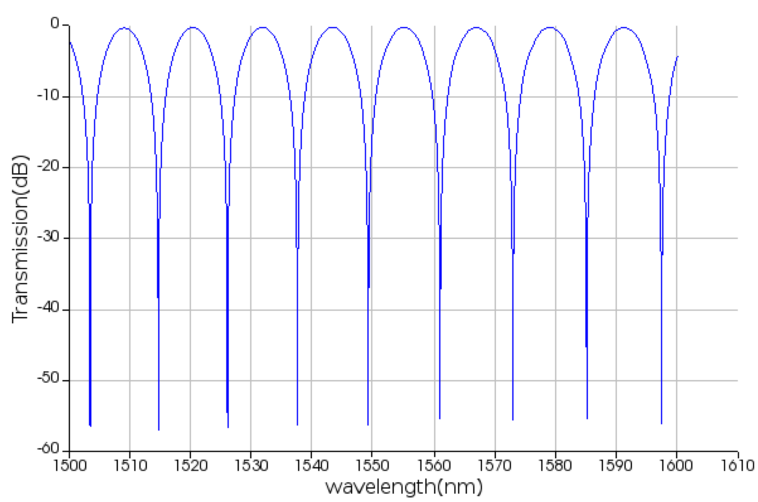

Figure 2: Illustration of electric field intensity distributions of the TE mode in a 220 × 500 nm silicon waveguide at Telecom wavelengths. The Si waveguide core (neff = 3.47) is buried in half water and half SiO_2 layers 4um each.

3 Conclusion

In conclusion, 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. Overall, the results of the project demonstrate the potential of silicon photonics-based biosensors to revolutionize the way that medical diagnoses are performed, enabling more effective and sustainable approaches to healthcare.

References

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