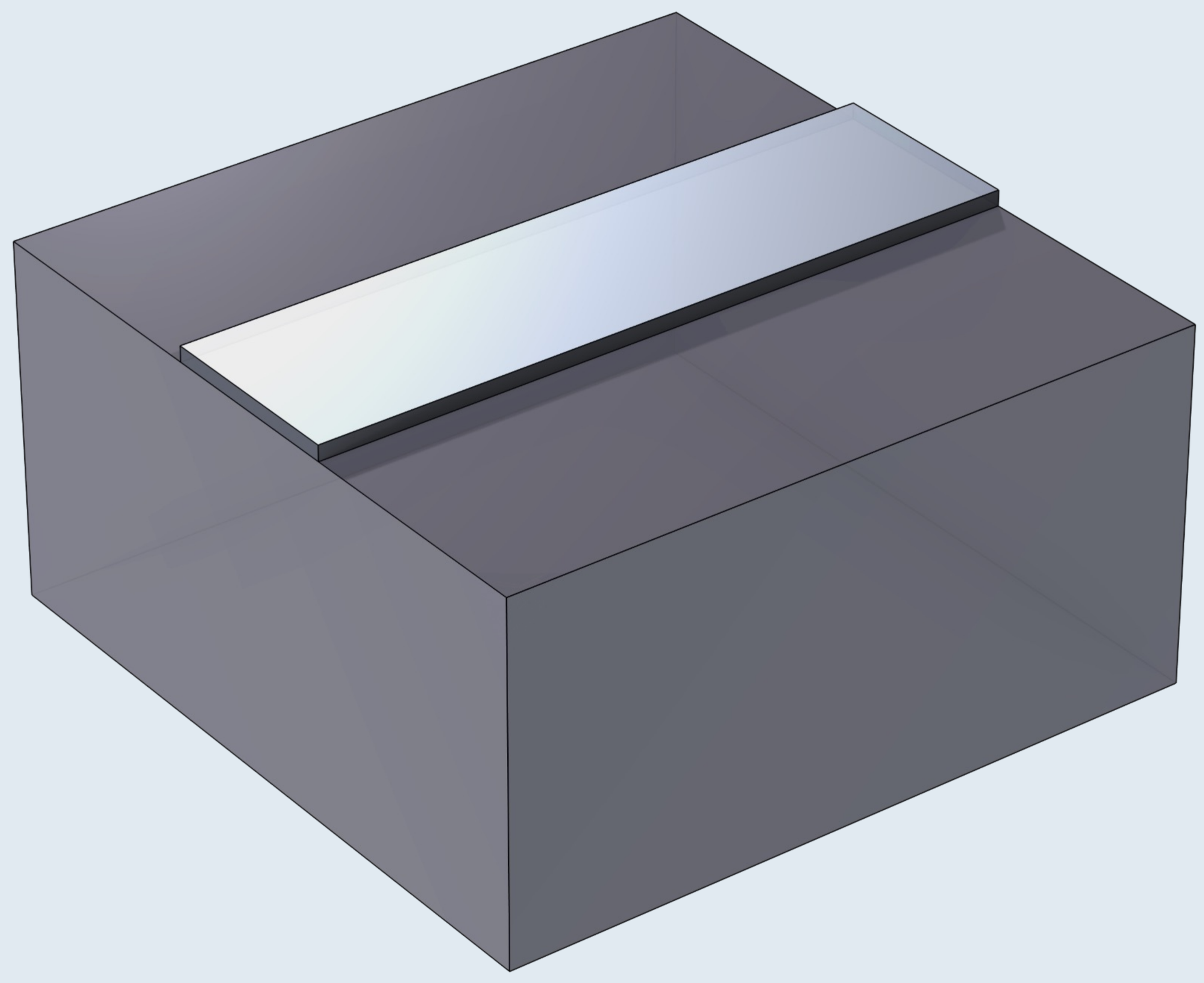

Design of a Transverse Electric Single Mode Silicon-On-Insulator Waveguide for Sensing Purposes

An air-clad 2.8 x 0.22 μm^2 SOI strip waveguide was designed and evaluated to strengthen the interaction between guided electro-magnetic radiation and surrounding environment. The waveguide is developed for λ = 4.234 µm where a strong carbon dioxide (CO_2) absorption feature is localized.

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Abstract

This study aims to develop a compact optical sensing architecture for trace gas detection purposes. We designed a 2.8 x 0.22 μm^2 silicon (Si) strip waveguide on a silicon dioxide/silica (SiO_2) substrate – and without considering a superstrate – for a wavelength (λ) of 4.234 µm, where a strong CO_2 absorption feature is localized. 2D and 3D evaluations were numerically performed, achieving a Transverse Electric (TE) single mode operation through parametric optimization.

By removing the top layer (*i.e.*, superstrate), the evanescent field of the guided electro-magnetic radiation can extend beyond the physical edge of waveguide core, thus interacting directly with the gas molecules in the surrounding environment. At waveguide output, a sensitive element (*i.e.*, a detector) can be placed to detect the effects of this interaction, thus developing a portable sensing system for environmental monitoring and industrial applications, among others.

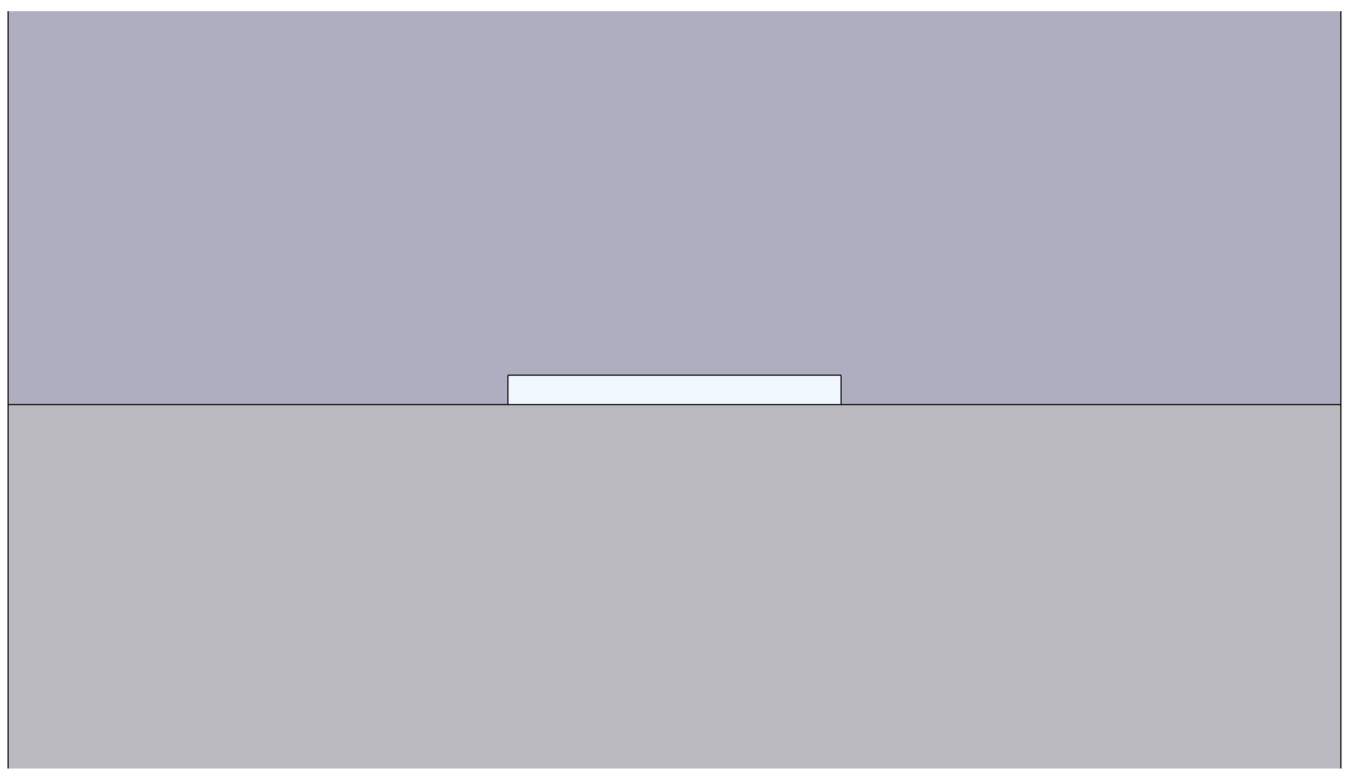

FIGURE 1. 2D section of the waveguide overall structure. Top: Air superstrate. Middle: Silicon waveguide core. Bottom: Silica substrate.

Methodology

A material refractive index of 1, 3.43, and 1.38 was considered for the air superstrate, silicon waveguide core, and silica substrate, respectively, at an operating wavelength of λ = 4.234 µm. Sub- and superstrate were 10 µm wide and 5 µm thick.

A 2D Study (*i.e.*, **Mode Analysis**) was performed to evaluate both the effective index and the field profile distribution of the Transverse Electric (TE) fundamental mode of the waveguide showing the strongest evanescent field intensity by optimizing both width and thickness of waveguide core. To accomplish this task, the **Electromagnetic Waves**, **Frequency Domain** (**ewfd**) interface – within the **Wave Optics Module** – was employed.

Results

An effective index of 1.75 for the TE single mode of the waveguide was retrieved. The dispersion curve was also determined showing a TE single mode behaviour of the overall structure for a waveguide core width between 2 µm and 2.9 µm. Considering a waveguide core width of 2.8 µm, a waveguide core thickness of 0.22 µm, and a wavelength of 4.234 µm, the field profile distribution of the TE fundamental mode is shown in Figure 2.

In addition, through the implementation of integration operators, the fractional amount of guided radiation inside the single simulation domains was estimated: 34% in waveguide core and 27% in waveguide superstrate (*i.e.*, beyond physical edge of waveguide core).

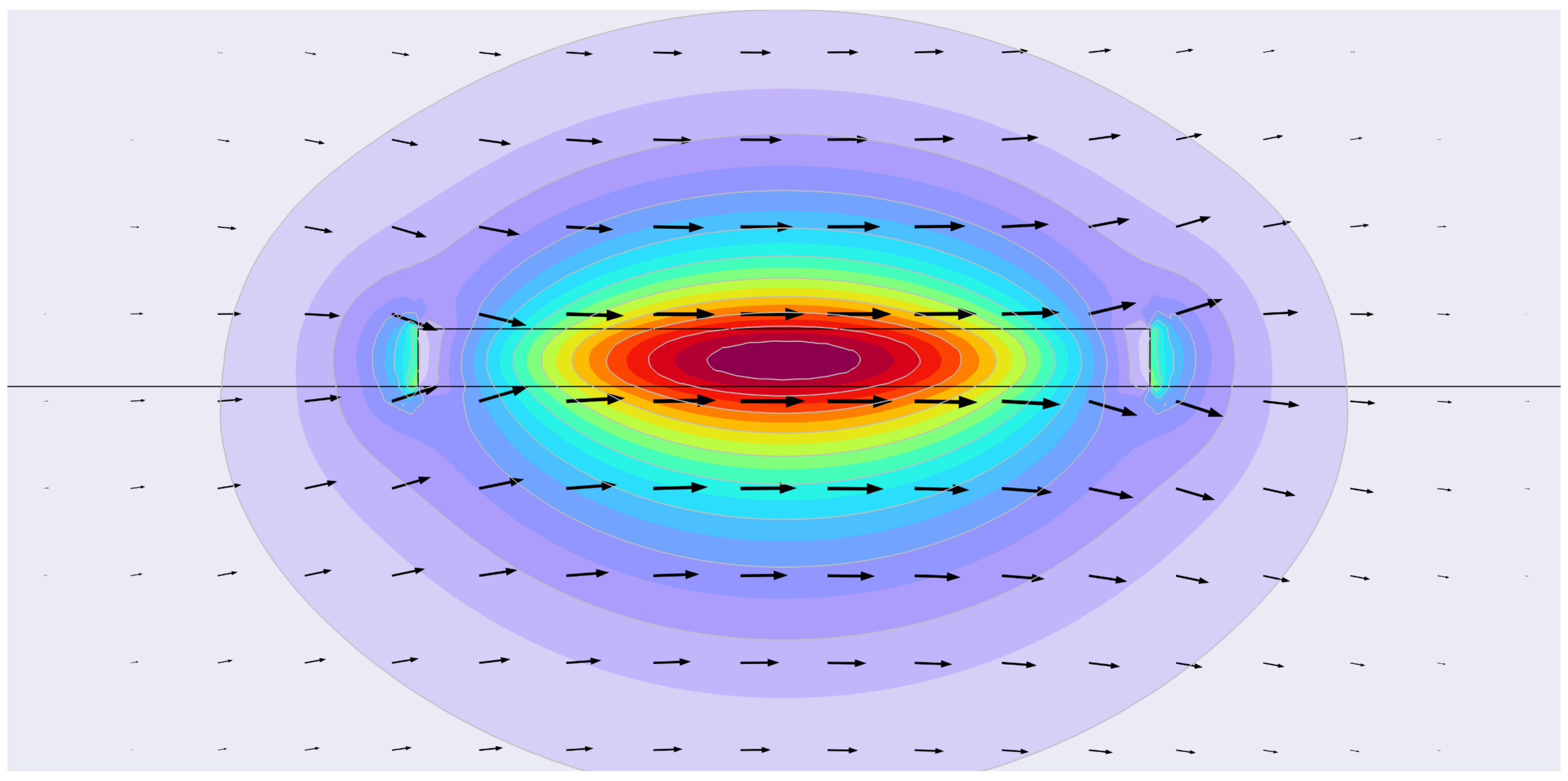

FIGURE 2. Field profile distribution of the TE single mode of waveguide. Surface: Electric field. Arrow Surface: Electric field. Contour: Electric field.

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