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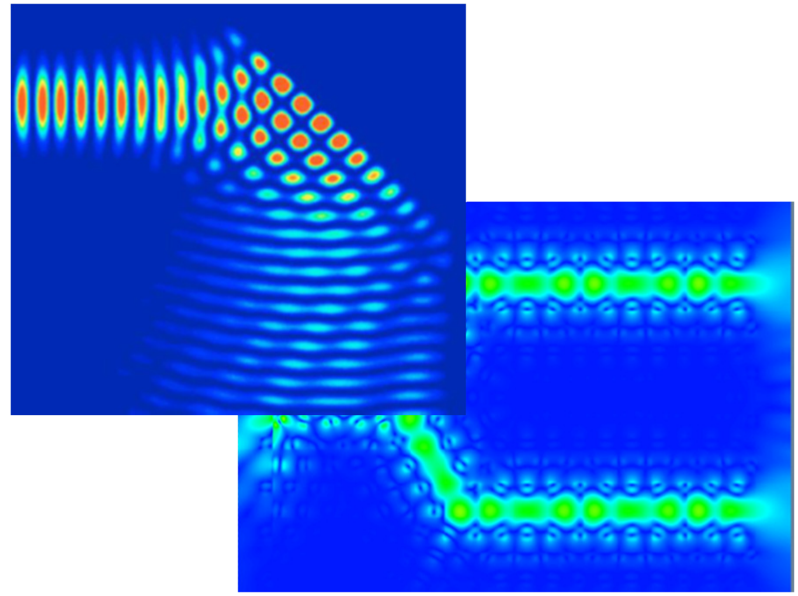
OptiFDTD

Finite-Difference Time-Domain
Simulation Design



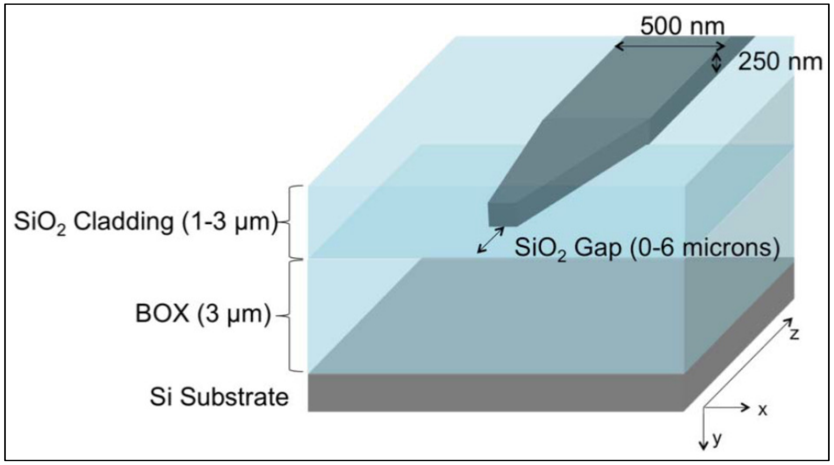
Silicon nanotapers for fiber-to-waveguide coupling

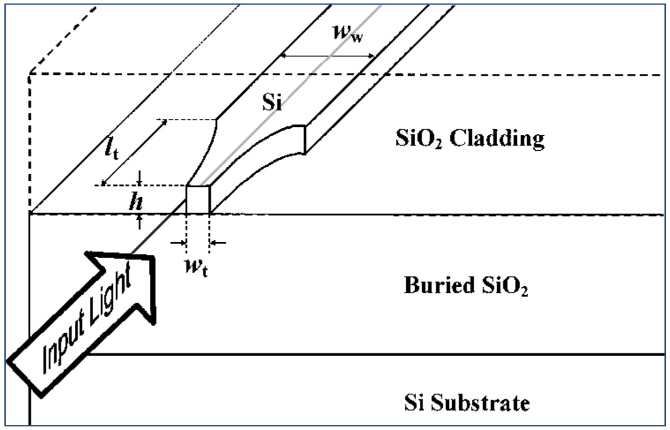
7 Capella Court
Nepean, ON, Canada
K2E 7X1

+1 (613) 224-4700
www.optiwave.com

Introduction

- The two main approaches for coupling light on a high-confinement chip with sub-micron waveguides are gratings, or taper couplers. [1]
- The coupler is composed of high-index-contrast materials and is based on a short taper with a nanometer-sized tip. [2]
- The tapered coupler is actually a compact mode convertor between a fiber and a sub-micrometer waveguide. [2]
- The tapered coupler can be linear [1] or parabolic [2] transition.
- Silicon-on-insulator (SOI) technology was chosen as the platform for the nanotaper and waveguides because it provides a high-index contrast, includes a SiO_2 layer as an optical buffer, and permits compatibility with integrated electronic circuits. [2]





[1] Jaime Cardenas, et al., "High Coupling Efficiency Etched Facet Tapers in Silicon Waveguides," IEEE Phot. Tech. Lett. VOL. 26, NO. 23, 2380-2382 (2014)
*[2] Vilson R. Almeida, et al., "Nanotaper for compact mode conversion," Opt. Lett. **28,** 1302-1304 (2003);*

3D FDTD simulation

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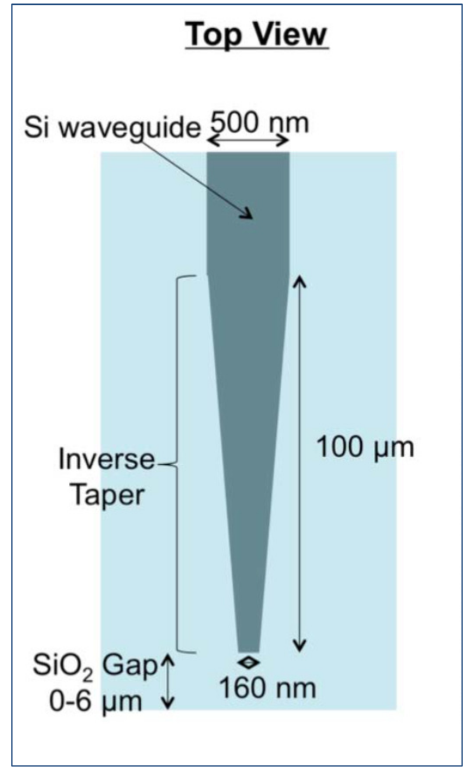
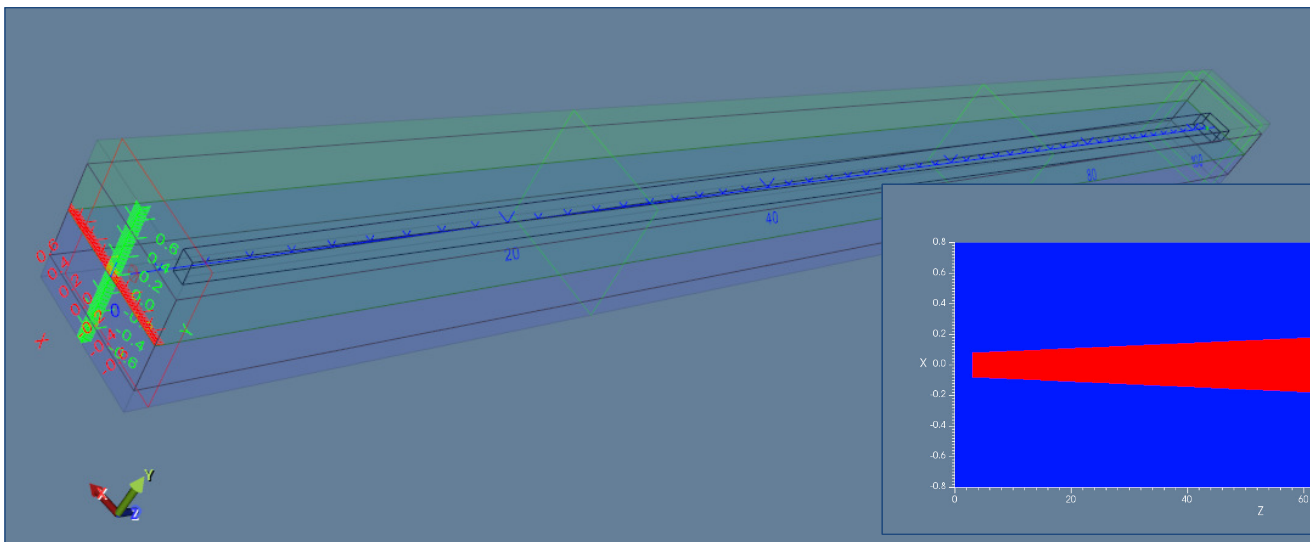
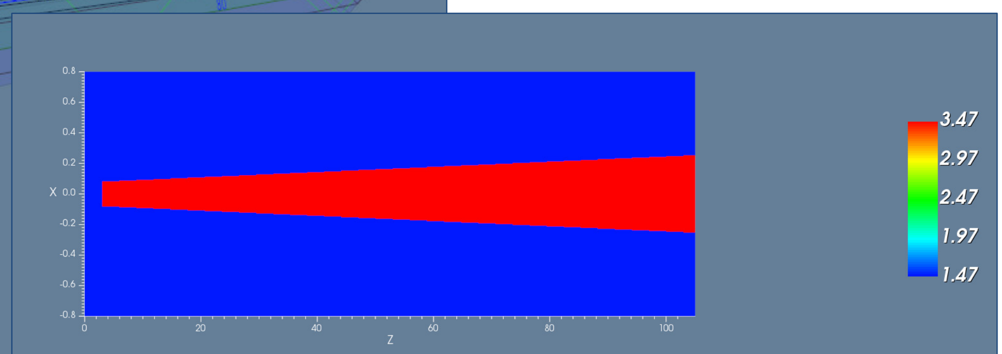
- The key component to be simulated is the linearly tapered Si waveguide (160 nm to 500 nm width change over 100 um length, 250 nm height) from Ref. [1], which is buried in SiO_2 waveguide (Note: A reduced size was used (1.5 um × 1.5 um × 105 um) to allow for a faster simulation time)
- For the accurate simulation of a linearly tapered Si waveguide, the mesh size for the taper should be fine, therefore non-uniform mesh is used in this case.
- The optical source is set as CW (λ=1.55 um) in the time domain with a Gaussian transverse profile in the spatial domain and is located at the Si paper tip of the SiO_2 waveguide.

Note: The simulation time should be made long enough to ensure a steady state result







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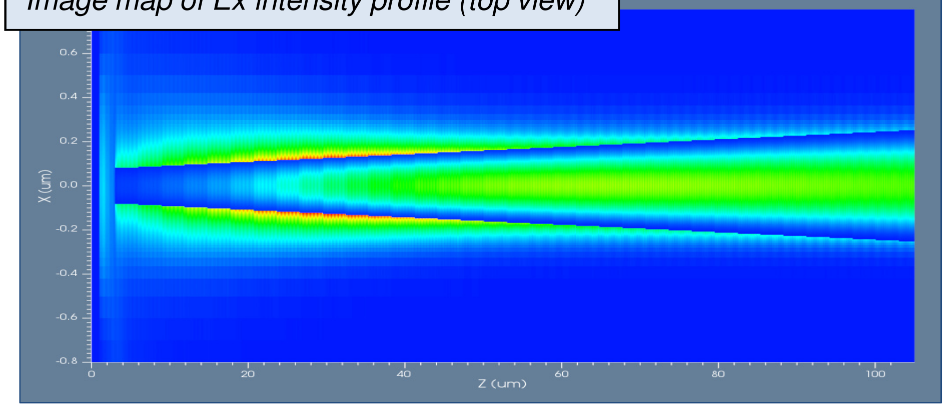
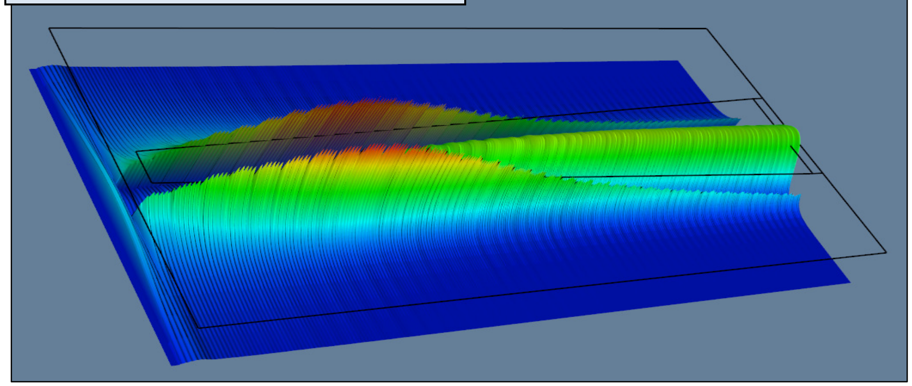
Simulation results

Image map of Ex intensity profile (top view)

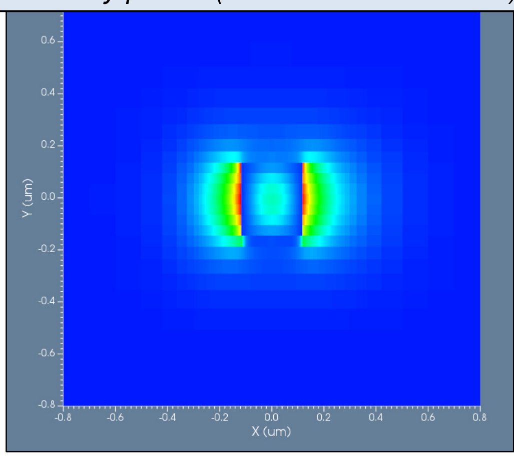


Height plot of Ex intensity profile

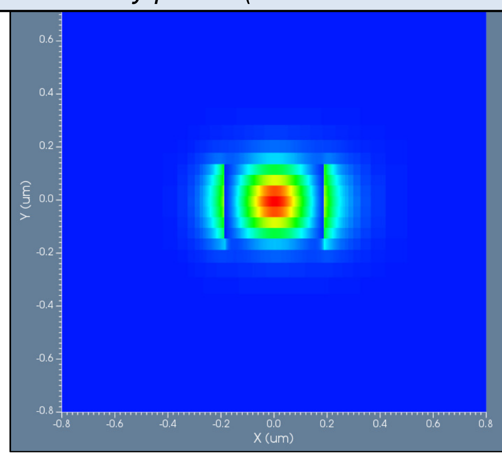


- The top view demonstrates the efficient coupling of the tapered Si waveguide.
- The bottom view shows the mode conversion at different positions (left: 25 um, middle: 65 um, right: 103 um)

Ex intensity profile (cross section – 25 um)



Ex intensity profile (cross section – 65 um)



Ex intensity profile (cross section – 103 um)