Introduction

Photonics is the backbone of modern Fiber Optic Communication. In Fiber Optic Communication, information is encoded in the form of light pulses and transmitted via Optical fibers at the speed of light. Light from a light source such as a Semiconductor Laser goes to an Optical modulator, where it gets modulated, then passes through an Optical fiber, and is detected by a Photodetector which converts it back into an electrical signal.

Silicon Photonics involves fabricating Photonic components using standard Complementary Metal Oxide Semiconductor (CMOS) processing techniques. A light source, Optical modulator, Optical waveguide which is analogous to an Optical fiber for guiding light, and Photodetector are made on a Silicon substrate. Due to CMOS scaling, several operational problems and heating issues have arisen, mainly due to copper interconnects between different CMOS components. In Si Photonics, Optical waveguides are replaced with the conventional copper interconnects. This method of data transmission greatly reduced the heat dissipation and improved the performance and bandwidth. The data transmission through Optical waveguides needed all the Photonic components to be integrated on a single chip, which is called the Si Photonics technology.

Theory

In this project, a standard Optical modulator such as Mach-Zehnder Interferometer is implemented on a Si chip. Experimental data is compared to the simulation results and basic principles of the modulator are understood. The circuit consists of Fiber gratings connected to a Mach-Zehnder Interferometer on either side. Fiber gratings are used to couple light into and from an Optical waveguide to an Optical fiber. A Mach-Zehnder Interferometer has a Y splitter that splits incoming light into two channels and a Y coupler at the other end that combines the two light signals. The path length or phase shift of the light passing through the channels is varied. If the path length or phase shift in both channels is the same, light undergoes constructive interference, after it passes through theY coupler. The constructive interference is equivalent to a high Voltage and a digital output of 1. If the path length or phase shift between the channels is different, destructive interference occurs, equivalent to a low Voltage and a digital output of 0. The modulation of phase or path length is performed by varying the current or temperature across the semiconductor.

In the current project, a passive Interferometer is designed. Light from an external laser source is coupled into the Interferometer via fiber gratings and passes through the Interferometer. The transmission spectrum from the Interferometer is measured by scanning the wavelength of the laser source. The Interferometer consists of a y splitter connected to straight waveguides via a bent section. The straight waveguides have different lengths to get the desired phase shift difference. The straight waveguides are connected to the y combiner on the other side, via a second bent section. Fig.1 shows the schematic of a Interferometer made using Gds factory modules on python and displayed on K-layout.

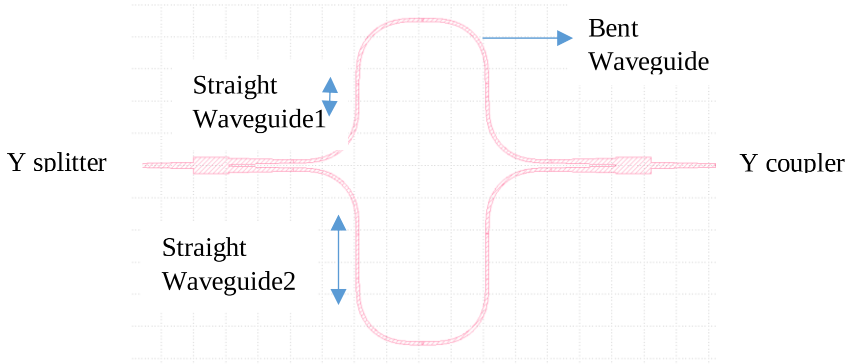
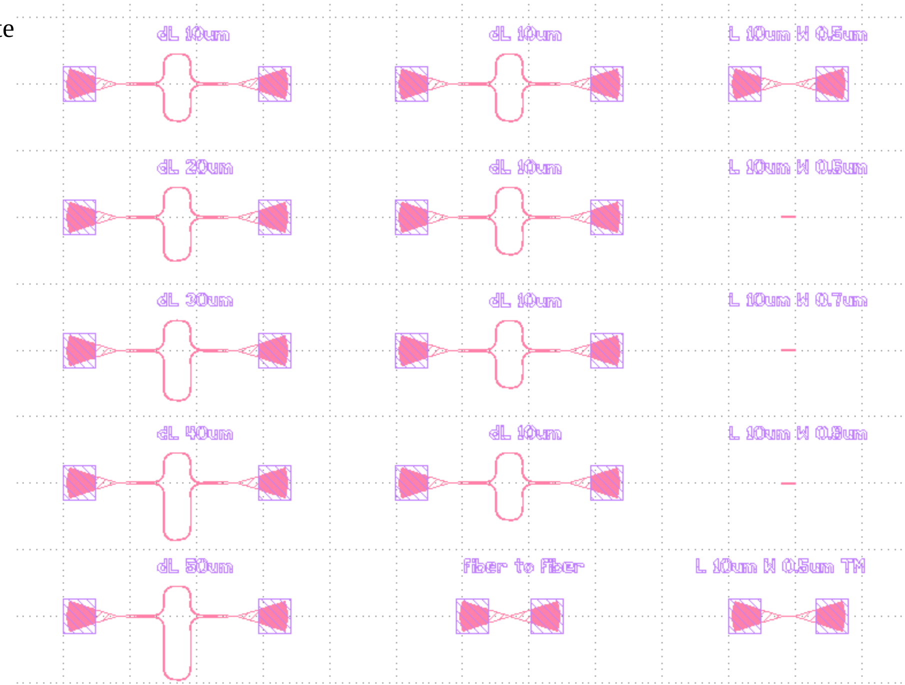


Fig.1: Schematic of an Interferometer, Straight Waveguide1=2um, Straight Waveguide2=7um, Path length=10um

The straight section length of the shorter channel, which we call Straight Waveguide1 is set to 2um. The longer arm's straight section length is the sum of shorter arm length and the path difference. Path difference of 10um, 20um, 30um, 40um, 50um are designed. The design with path length difference of 10um is included five times to study the fabrication variations. The designs with 500nm, 600nm, 700nm, 800nm width for a straight waveguide are included to observe the effect of width on wave guiding properties. The fiber grating coupler initial width is 500nm. An adiabatic coupler has to be included between the straight section waveguides with widths>500nm to smoothly transition to fiber grating coupler. It is yet to be done. Fiber to Fiber coupling loss will be analyzed using a design where the fiber grating couplers are joined directly. A design with a straight waveguide of width 500nm along with fiber grating coupler with TM mode coupling is included, to study the TM mode propagation. A rudimentary layout of the designs is shown below. The left most column consists of designs with varying path lengths. The center column consists is repetition of design1, with path length of 10um. The bottom design in center column consists of fiber grating couplers joined to each other. The right most column consists of straight waveguides of varying widths. The bottom design in right column consists of straight section with width of 500nm, but grating couplers designed for TM mode, inste



Modelling and simulation

The compact model of the waveguides included in the mask design will be calculated by Finite element modeling. The compact model consists of effective index, group index and higher order dispersion terms.

Compact equation for the waveguide: TBD

Transfer function of the device:

Effective index vs Lambda:

Group index vs Lambda:

Variation in Length:

Free spectral range vs Length:

Power splitting vs Length:

Fabrication: TBD

Experiment data: TBD

Analysis: TBD

Conclusion: TBD

References