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Student Paper

Electro-Optical Modulator Performance in SOI

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Since 1980's, silicon photonic devices have been extensively studied, however a submicrometre-size photonic devices have been realized only in the last few years. Silicon properties namely the transparency in the range of optical telecommunications wavelengths and high index of refraction, have enabled the fabrication of low loss submicron waveguide. Photonic devices such as splitter, coupler, and filter have been demonstrated in silicon but once the device has been fabricated, the properties of the device are predetermined. A silicon based modulator can be used to control the flow of light, where the refractive index of the silicon waveguide can be varied thus, induce a change in the transmission properties.

This paper highlights the study of carrier injection effect on silicon waveguide with p-i-n diode structure integrated on Silicon-on-Insulator (SOI). The device performance is predicted using 2D Silvaco CAD software under different applied voltages at 1.55 µm.

We studied the micrometer scale silicon modulator based on the p-i-n diode structure to be operated at 1.55µm optical wavelength as depicted in Fig. 1. The P^+ type region is implanted with $5x10^{19}$ cm^3 Boron concentrations while the N^+ type region is the phosphorus implanted region with a concentration of $5x10^{19}$ cm^3. The structures have the background doping concentrations of $1x\ 10^{14}$. The depth of the implanted region is about 1.8 µm for N^+ region and 1.6 µm for P^+ region. The rib height and width of the structure is chosen in order to have a single mode behaviour. The rib structure is designed to have 4 µm in height and 4 µm in width. With the chosen doping concentrations for the structure, the distance of the doped regions to the rib sidewalls turns to be 1.4 µm.The optical power of 1mW is applied to our design of phase modulator and the effect of the refractive index at 1.55µm optical wavelength is investigated. The important parameters used in the simulations are shown in Table 1.

The performance of the modulator is evaluated in terms of its modulation efficiency and absorption loss as in Fig. 2 and Fig. 3. Modulation efficiency ($V\pi L\pi$) is minimized at a greater applied voltage. Nevertheless, the absorption loss increased at higher injected free carriers. Therefore, appropriate selection of parameters is crucial according to design of the modulator.

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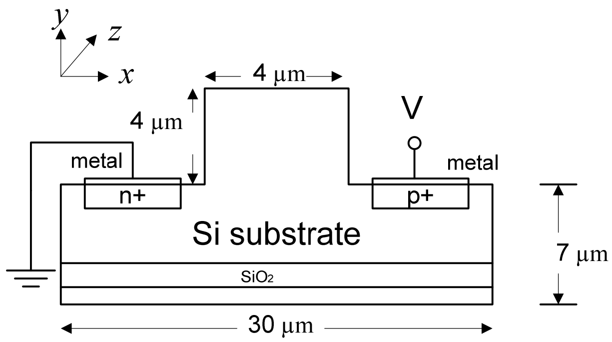

TABLE I
SIMULATION PARAMETERS

Si refractive index	3.475
Si background carrier conc. (cm^3)	$1x10^{14}$
τ_p (s)	$2x10^{-6}$
T_n (s)	$2x10^{-6}$
Temperature (K)	300

Fig. 1. Cross section of the p-i-n phase modulator.

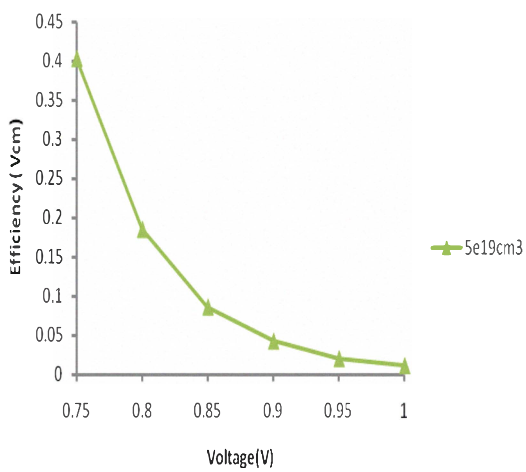

Fig. 2. Modulation effeciency for different applied voltage

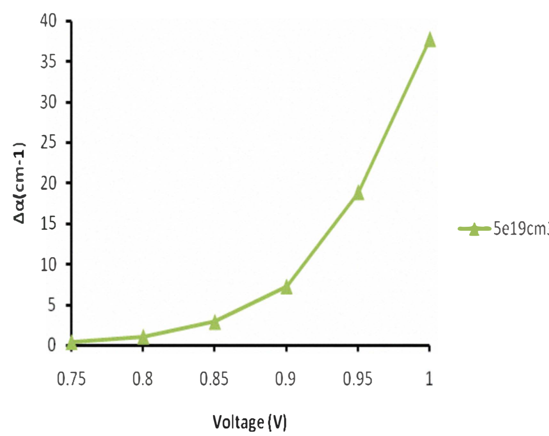

Fig. 3. Variation of absorption for different applied voltage