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Mach-Zehnder Interferometer Optical Modulator Using Cascaded p/n Junctions and Photonic Crystal

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Introduction

Silicon nanophotonics has been emerged as a key platform for various optical devices as well as systems. Metal based interconnection technology is facing severe challenges due to bandwidth demand for high performance computing. Silicon photonics based optical interconnects are cost effective as well as higher bandwidth. Light modulation in silicon is achieved by varying the carrier density to change the local index of refraction [1]. We demonstrate photonic crystal based Mach-Zehnder Interferometer (MZI) modulator with cascaded p/n junctions which are arranged as shown in Fig. 1(a) and compare with non-photonic crystal based MZI modulator with cascaded p/n junctions as shown in Fig. 1(b). In the photonic crystal based MZI light is strongly confined into waveguide for that lower loss is introduced.

Fabrication process

The MZI optical modulator was fabricated on silicon-on-insulator (SOI) wafer. A silicon oxide layer of 100 nm is formed on the SOI wafer. The SiO_2 layer is then patterned to waveguide using as hard mask of etching the top silicon layer. After that p and n regions are made by ion implantation, photonic crystals are formed by electron beam lithography and etching. The SiO_2 layer is deposited by atmospheric pressure chemical vapor deposition (APCVD) and this layer acts as an insulator as well as upper cladding layer. Finally, Al electrodes are fabricated after contact hole wet etching, by the DC magnetron sputtering and H_2+N_2 annealing is carried out.

Results and discussion

Simulated output intensity of both photonic crystal and non-photonic crystal based structure are shown in Fig. 2. The output of non-photonic structure becomes smaller due to its several loss factor. In the non-photonic structure a part of light are not confine into the waveguide and for that light reflection occurred from p and n bridges. Loss calculation was done by Rsoft-FullWAVE simulator and then output intensity was calculated by $I\text{-}_0e^{-\alpha d}$, where I_0 is the input power, α is the loss and d is the waveguide length.

Conclusion

The MZI using photonic crystal has shown much more output intensity by overcoming such type of reflection loss.

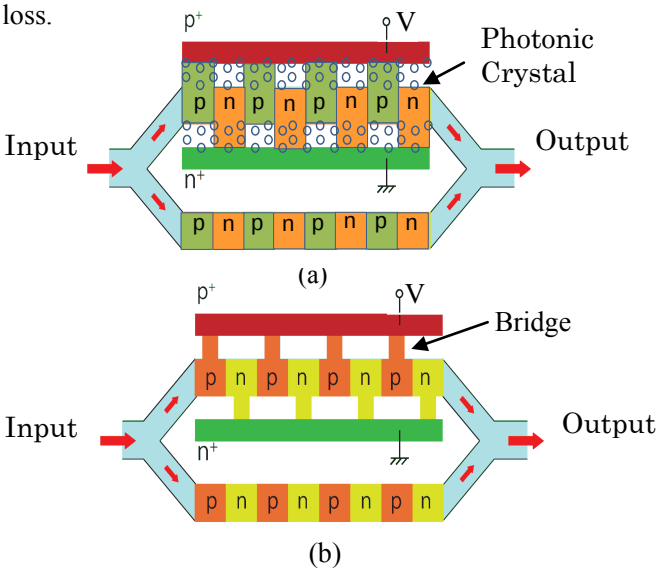

Fig. 1 Structure of cascaded p/n junctions based MZI optical modulator (a) with photonic crystal (b) without photonic crystal [2].

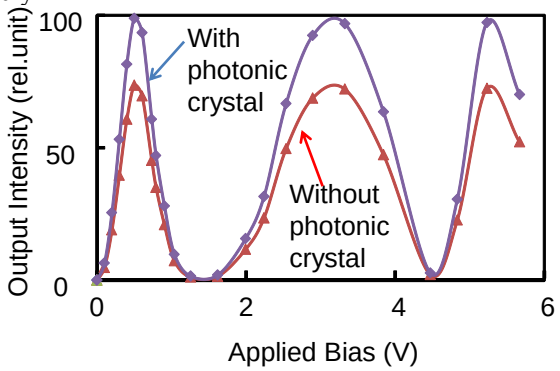

Fig. 2 Applied bias versus output intensity of MZI modulator with photonic crystal and without photonic crystal.

References

1. Zhi-Yong Li *et al.*: OPTICS EXPRESS **17** (2009) 15948.
2. R. Furutani *et al.*: Proceedings of SPIE,Silicon Photonic Integrated Circuits III **8431** (2012) 84310W.