Feasibility Study of 1×4 Optical Mode Switch Based on Single Dimensional Mode-set

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1. Introduction

In order to cope with the growing communication traffic to or from data center, we have proposed ROADM (Reconfigurable Optical Add/Drop Multiplexer) based on spatial single dimensional mode [1]. In this system, optical mode switch is one of the key-device. We have already proposed the 1×N switch based on single dimensional mode-set with mode coupler configuration, but the feasibility of 1×N mode switch was not yet reported [2].

In this work, we report the feasibility study of the 1×4 optical mode switch considering modes switching among 0^{th}, 1^{st}, 2^{nd} and 3^{rd} mode. The estimated internal loss for 0^{th} mode, 1^{st} mode, 2^{nd} mode and 3^{rd} mode are -0.567 dB, -0.602 dB, -1.008 dB, -0.947 dB respectively.

2. Structure of 1×4 optical mode switch

The spatial one-dimensional mode is a mode that has one or more standing wave peaks only in the horizontal direction (one dimension) of the optical signal in the rectangular waveguide. Utilizing single dimensional mode-set is easy to realize higher mode extension.

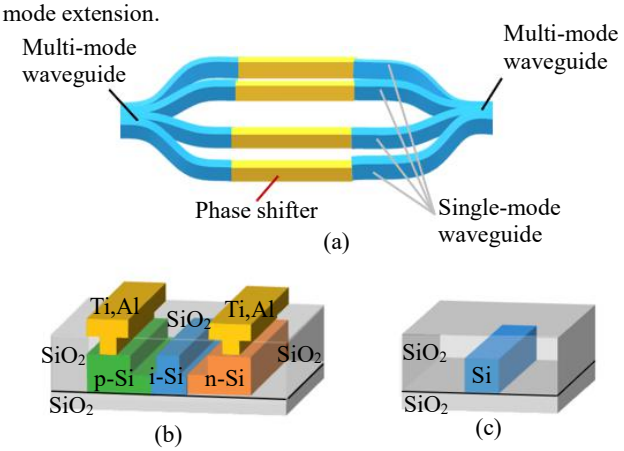

Fig. 1. (a) The schematic diagram of the proposed 1×4 optical mode switch, (b) The structure of p-i-n trench, and (c) The structure of the waveguide

The schematic diagram of a 1×4 optical mode switch configuration is shown as an example in Fig. 1 (a). The 1×4 optical mode switch is designed with four symmetrical arms with refractive index change region in each arm. We assumed the refractive index is changed by plasma effect with current injection, the p-i-n trench structure in phase shifter is shown in Fig. 1 (b), the waveguide structure is shown in Fig. 1 (c) [3]. The input port is divided by Y-junction that separates eigen-mode into 4 single mode in each arm. Then the separated light is coupled toward output four mode waveguide. This 1×4 optical mode switch secures the switching from one mode to another one. 1×4 optical mode switch is operated by electric current injection into pin phase shifters. Lateral pin structure makes π difference of phase-shift at each arm, which leads to mode-change in the output signal.

3. Simulation results and discussions

Simulation results of transmittance for modes switching is shown in Fig. 2. Beam propagation method (BPM) was used for the simulation. The injected light is with 0^{th} mode. The relationship of refractive index change, phase shift and injected current in shown in table 1. We assumed plasma effect with current injection to generate a π phase shift. The estimated necessary current is 6 mA to get π phase shift of phase shifter by calculation.

Tab. 1 Relationship of refractive index change, phase shift and injected current

Refractive index change (10^{-3})	0.25	0.5	0.75	1	1.25	1.5
Phase shift	0.17π	0.33π	0.5π	0.67π	0.83π	π
Current (mA)	0.11	0.24	0.5	1.45	2.85	6.12

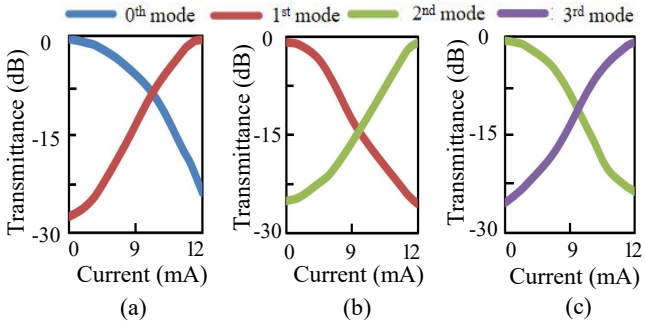

Fig. 2. Transmittance for 1×4 optical mode switch. (a) 0^{th} mode is switched to 1^{st} mode, (b) 1^{st} mode is switched to 2^{nd} mode, and (c) 2^{nd} mode is switched to 3^{rd} mode

4. Conclusion

We have studied the feasibility study of the 1×4 optical mode switch by modes switching and got the internal loss of 0^{th} mode, 1^{st} mode, 2^{nd} mode and 3^{rd} mode are -0.567 dB, -0.602 dB, -1.008 dB, -0.947 dB respectively.

Acknowledgement

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Reference

[1] K. Hamamoto et al, Proc. Adv. Photon., PTh1D.4, 27 (2017).
[2] S. Ogawa et al, IEICES, 5, 105(2019).
[3] H. Jiang et al, IEICE Electronics, E100-C, 782 (2017).