A Novel 1×3 Power Splitter Using Coherently Coupled Effect With Asymmetric Branching Ratio

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Abstract --- *Based on the coherent-coupling effect, a novel asymmetric branching ratio 1×3 power splitter with Ti-diffused* $LiNbO_3$ *device is proposed. The 1×3 power splitter consists of a coherent-coupling bending waveguide and two straight waveguide.*

Keywords: *coherent-coupling effect, power splitter.*

INTRODUCTION

1×3 power splitter is a fundamental element for integrated optical field. Recently, high-density optical integrated circuits have attracted interest of the public. In order to increase the density of optical components on the same chip, developing a 1×3 branching waveguide with a large branching angle is of great significance. A 1 ×3 power splitter usually used for equal powering and widely research by different authors. Several efforts have been made to overcome the loss problem, especially when the branching angle is large. We found out many kind of resource at those proposed, but it still perplexity to used mircoprisms or axis shift. We proposed a novel 1×3 power splitter based on coherent-coupling effect. To fabricate the 1×3 branching, firstly we use a abrupt band waveguide to make a coherent-couple effect[1]- [3], then inserted a straight waveguide to take shape 1×3 branching. There are several merit in our proposed, the structure simply, only two photolithographic steps are required, which greatly simplifies the fabrication process. And we depend on Beam propagation method (BPM), to fabricate and design our proposed device. In this paper, our proposed 1×3 branching device used position shifting and coherent-couple to variable the power output ratio.

DESIGN AND SIMULATION RESULTS

In this paper, based on the coherent-coupling effect, we propose a novel 1×3 power splitter with Ti-diffused LiNbO3 waveguide. The coherent coupling effect among closely spaced abrupt bends was originally described by Taylor for the analysis of power exchange between guided and radiation modes at the corner of the bend[4]. An abrupt bend generates a radiation field that interacts with the guided mode. As a result, the phase front of the total field rocks while the intensity is almost unchanged[5] [6]. Thus, the peak value of the coherent coupling waveguide is defined by the following equation

$$L_c = \frac{(2m+1)}{2\Delta_n}\lambda \qquad (1)$$

,where λ represents wavelength, Δ_n represents difference of refraction index between guiding mode and radiation mode, and L_c represents coherent coupling length. This equation helps us to design the coherent coupling waveguide and calculate the position where the straight waveguide separated from the coherent-coupling waveguide. A schematic diagram of the proposed 1×3 power splitter is shown in the Fig. 1.

In the event that the waveguide is excited by a transverse-electric (TE) eigenmode at 1.55 μm, and the evolution of optical power along the device is calculated by using a commercially available beam propagation method software, the result as set of in the Fig. 2 shows the normalized power distribution at the output port A and output port B along the device angle for θ= 3˚. In regard to physical mechanism, the curve wave will change due to the variation of the distributing of refractive index; therefore, the field passing by the refractive index is mutually different and gives rise to an unmatched problem, then inspires up radiation mode. These radiate modes will along with guiding mode interfere with each other. When both modes mutually differ (2m+1) π, radiation mode will match a time to lead guiding mode; therefore, the combination of the foregoing modes provides contribution towards delivering a rate. Johnson[3] has ever raised a viewpoint that the total energy of the waveguide will be influenced by the light field energy and the degree of the light wave phase. Johnson has ever analyzed the mode that has been curved will be leading of fraction optics mode and radiation mode and both of the mode are distributed as field form. We consider the phase of the optics field is te main factor of coherence coupling occurrence. While each of the bended waveguide radiate mode and the guiding mode interferes with each other at segment 2 waveguide; relevant phase of the optics field will be showed.

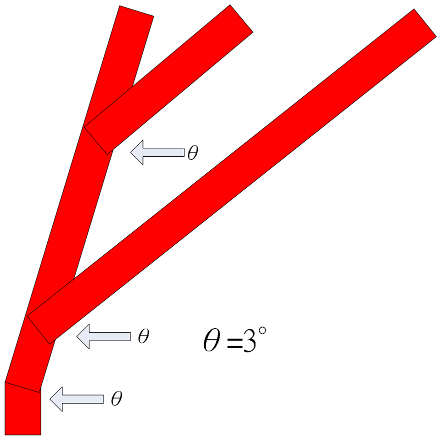

Fig. 1. Schematic diagramof the proposed 1×3 power splitter.

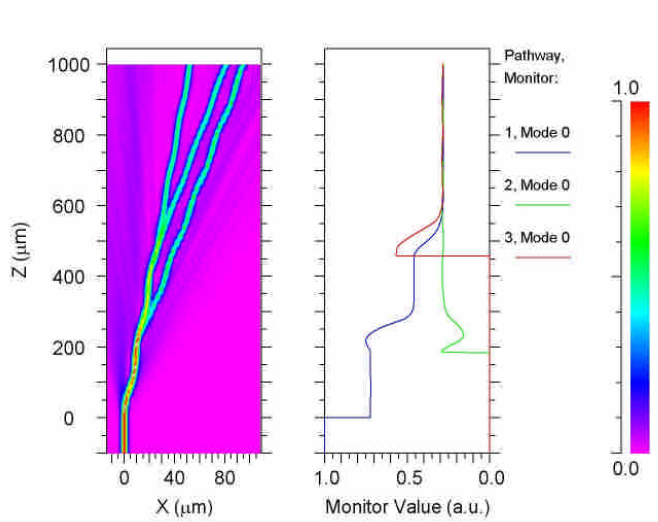

Fig. 2. Output power of the proposed 1×3 power splitter.

CONCLUSIONS

A 1x3 power splitter by Ti-diffused LiNbO3 waveguide has been proposed in this paper, this device owns 3° angle and 90% power transmit efficiency. The functional advantage of this splitter device lies in its 1x3 power. Besides, the part of this device is that it only applies two mask process to achieve various kinds of power ratio. Based on the above concepts, we will continue to explore and develop the application of the proposed 1x3 branching structure on integrated optical devices, such as tree type power splitter. The detailed statement and demonstration will be proposed later.

REFERENCES

[1] H. F. Taylor, “Power loss at directional change in dielectricwaveguides,” Appl. Opt., vol. 13, pp. 642–647, 1974.

[2] H. F. Taylor, “Losses at corner bends in dielectric waveguides,” Appl. Opt., vol. 16, no. 3, pp. 711–716, 1977.

[3] L. M. Johnson, and D. Yap, “Theoretical analysis of coherently coupled waveguide bends,” Appl. Opt., Vol.23, pp.2988-2990, 1984.

[4] H. B. Lin, R. S. Cheng, and W. S. Wang, “Wide-angle low-loss singlemode symmetric Y-junction,” IEEE Photon. Technol. Lett., vol. 6, pp.825–827, 1994.

[5] C. W. Hsu, H. L. Chen, and W. S. Wang, “Compact Y -Branch Power Splitter Based on Simplified Coherent Coupling” IEEE Photo. Tech. Lett., vol. 15, pp.1103-1105, 2003

[6] J. J. Su and W. S. Wang, “Novel coherently coupled multisectional bending optical waveguide,” IEEE Photon. Technol. Lett., vol. 14, pp. 1112–1114, 2002.