ISSN 2229-5518

Design of LiTaO3 1x2 Y-Branch Optical Power Splitter with S-Bend Waveguide and Study on the Variation of Transmitted Power with Branching Angle

S.Neelima[1], C.P. Vardhani[2]

Abstract—The device is initially a symmetric Y-junction based 1× 2 optical power splitter which is designed as that can deliver the best result in simulated performance. Symmetric Y-branch optical waveguide comprises of two S- bend waveguides However, a relatively better post fabrication performance is expected in terms of total insertion loss, non-uniformity and the polarization dependent loss. Beam propagation method is applied for this work, where S- bend waveguides are designed for optimal field matching in each Y-branch section of the optical splitter.

This article presents the study on variation of transmitted power with branching angle (the angle between the two S-bend waveguides), taking other parameters like wavelength and width of the components in this device as constant.

Key words : Beam propagation method · Insertion loss , Non- uniformity, Optical splitter, Polarization, dependent loss, Y- junction.

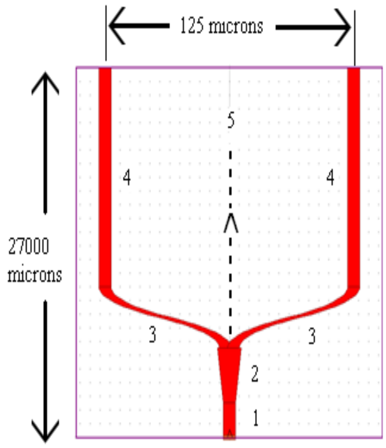
1.Introduction

Y-BRANCH waveguides are important passive devices in optical integrated circuits and have been widely used in power splitters, optical switches, and phase modulators. Typically, a Y-branch optical power splitter consists of a single waveguide splitting symmetrically into two waveguides. A single Y-branch is commonly used as a 1x2 power splitter as shown in Fig 1. Multiple Y-branch splitters are often cascading combined into $1x2^N$ optical power splitter where N is cascaded stages. The design is modified by incorporating a finite gap at the splitting junction, instead of zerogap to violates the adiabatic condition resulting in an extra insertion loss. Inclusion of this gap in the design slightly deteriorates the simulated performance of the splitter, however, a relatively better post fabrication performance is expected in terms of total insertion loss, non-uniformity and the polarization dependent loss. Beam propagation method is applied for this work, where S-bend waveguides are designed for optimal field matching in each Y-branch section of the optical splitter. Ideally, the input power is divided equally between the two waveguide arms to achieve equal power splitting and minimize coupling.

2. Design of the Y-branch Power Splitter

This device is designed using Titanium diffused Lithium Tantalate waveguides by RSOFT cad tool. Lithium Tantalate (LiTaO3) is an attractive host material for various applications due to its large electro-optic and nonlinear integrated property which can be used as an alternative to LiNbo3. Fig:1 illustrates the top view of the Y-branch optical power splitter.

This low loss single mode 1x2 Y-branch optical power splitter (Fig1) is formed of a straight input waveguide (for receiving an input signal), two S-bend sin arc waveguides that meet at the linearly tapered waveguide at its leading edge, joined to the input waveguide and two straight output waveguides that are attached to the two S-bend waveguides. A sharp inner edge is formed where the two waveguide meet, forming equal branching angle for the two S-bend waveguides, which facilitates equal (50/50) splitting of the Y-branch[1]. The output waveguide are symmetrical about the propagation axis which is along the length of the device. Wide gap between the two output waveguides is desirable for the reduction of excess losses [5]. The distance between the two output waveguides is 125µm (centre-to-centre). The total length of the device is 27000 µm. The taper length is 4mm and the width of the waveguides is 6µm.



1→ Straight input waveguide
2→Linearlytapered waveguide
3 → S-bend waveguides
4 → Straight output waveguide
5 → Direction of propagation

Fig1: Y-branch power splitter (Top view).

1 Research Scholar, Photonics Research Lab, Dept. of Physics, Osmania University, Hyd-07 e-mail:neelimapatnaik@rediffmail.com

2 Assistant Professor, Photonics Research Lab,Dept. of Physics,Osmania University, Hyd-07, A.P., India. e-mail:vardhani_c2001@yahoo.co.in

ISSN 2229-5518

3(i) Simulation and its Results

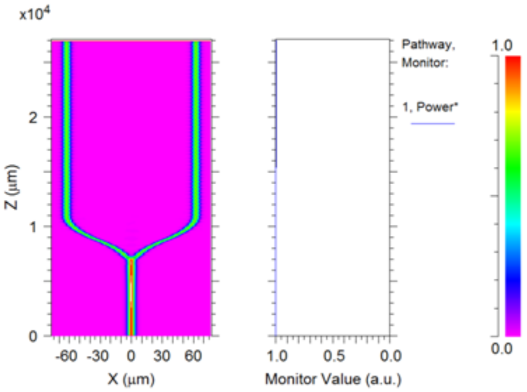


Fig2: simulation of optical signal in power splitter

3(ii) Mode Profiles

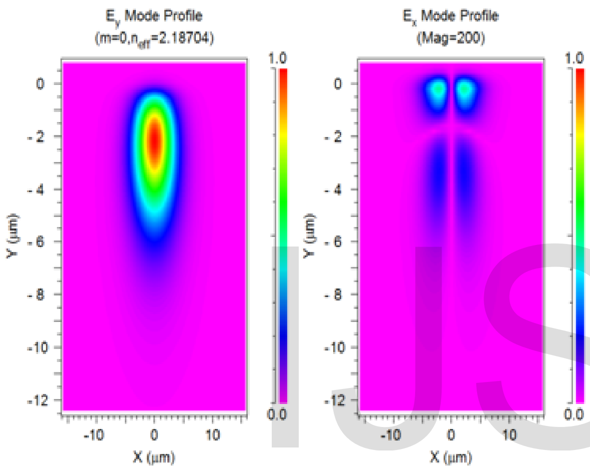


Fig3: Simulation of the Mode profile and effective refractive index across the width of the optical splitter at the wavelength 1550nm, Width 6μm.

The Beam propagation method is used to simulate and study the effects of variation of different parameters in this power splitter of length 27000μm.The red colour inside the straight input waveguide of the device indicates that the input power is 1 (Watt) which remains same till the branching starts in the device. As the branching starts the power splits in the two arms equally which is indicated by the green color in the two arms. Simulation is done by varying different parameters i.e. the branching angle, wavelength, and width one by one and keeping remaining parameters constant. The refractive indices of LT are no=2.178 and ne=2.180.The index difference is maintained to be $\Delta n = 0.002$.

Simulation result gives the transmitted power which is tabulated and the insertion loss (power loss) and the attenuation coefficients are then calculated using the following formulae:

$$\mathbf{IL = 10log_{10} (P_1/}\boldsymbol{P_2}\mathbf{)} \quad \text{dB} \qquad (1)$$

Where **IL** is the Insertion loss of an optical splitter and is usually measured in decibels (dB).

$\mathbf{P_1}$ is the given input power (1 Watt) and
$\mathbf{P_2}$ is the output transmitted power from both the arms together in Watts.

$$\boldsymbol{\alpha = IL/}\mathbf{L} \qquad \text{dB/mm}$$

α is the attenuation coefficient measured in decibels.
IL is the insertion loss in dB/mm.
L is the length of the device (27000μm).

4. Variation of Branching Angle

The branching angle 2θ degree is varied in the range 0.6degrees to 0.7degrees in steps of 0.02degree. The maximum transmitted power, P_2=0.992watts, for the input power P_1=1Watt, is obtained at the branch angle 2θ=0.62degrees with the other parameters kept constant i.e. wavelength=1550nm, width=6 μm, index difference=0.002.

5. Variation of transmitted power with branching angle is given in Table 1.

S.No.	Branching Angle $2\theta^0$	Transmitted Power P_2 (Watts)	Power loss (dB)	Attenuation coefficient $\alpha(dB*10^{-5})$
1	0.60	0.99105	0.0390	0.144
2	0.62	0.99284	0.0312	0.115
3	0.64	0.98926	0.0468	0.173
4	0.66	0.98926	0.0468	0.173
5	0.68	0.9874	0.055	0.203
6	0.70	0.9859	0.061	0.228

Table:1

6. Graph

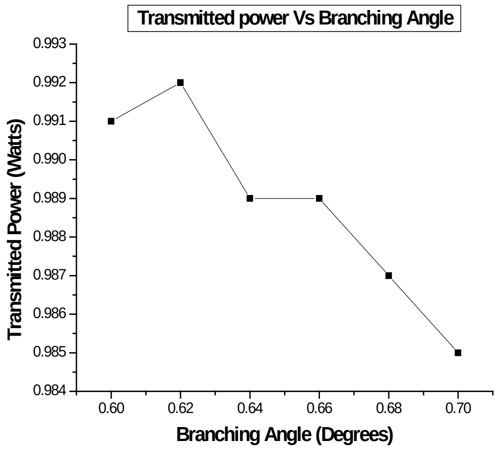


Fig4

From the Fig 4 it is clearly seen that as the branching angle increases transmitted power decreases Indicating that for low branching angle of the design transmitted power is with low losses.

CONCLUSION

On the Lithium Tantalate platform the Y-branch power splitter is designed and simulated. With the help of simulation results the variation of transmitted power with branching angle is studied. The insertion loss and the attenuation coefficient are calculated using the above mentioned formulae. It is found that this optical device is giving maximum output at wavelength 1550nm, branching angle 0.62degrees, and with width of the components as 6 µm. It is found that the power loss is less than 0.1 dB. This low loss results from Lithium Tantalate waveguides. Their model characteristics, fiber optic compatibility together with the ability to modulate the refractive index in the MHz range makes them a potential candidate for high accuracy interferometer sensors and optical fiber transceiver applications. One potential application is an integrated optic gyroscope.

Acknowledgement

We express thanks to DRDO (Delhi) for their financial support. CEERI (Pilani), and RCI (Hyderabad) Labs for their valuable suggestions.

References

[1] Journal of Modern Science and Technology Vol. 1. No. 1. May2013 Issue. Pp.176-187176 "Nano Structure Based Power Splitter Design by Using 2D Photonic Crystals "Md. Masruf Khan

[2] N. R. Council, Harnessing Light: Optical Science and Engineering for the 21st Century (National Academy Press (Washington, D.C.), 1998)

[3]

[4] United States Patent – Johannessen et al. Patent No. 6,970,625 B2, Nov. 2005

[5] Design of a low loss Y-branch optical waveguide _By Minoru SATITO, Hideki ONO and Hiromi TAKHASHI Jpn. J.Appl. Phys. Vol.38 (1999) PP.115-116, Part 1, No.1A, January 1999

[6] H Nishihara, M Haruna, and T Suhara, RE Fisher and W J Smith (Edi) in Optical Integrated Circuits, McGraw-Hill, USA, Optical and Electro-Optical Engineering Series, (1989).