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Research Article

Design and Simulation of 1x2 Y-branch optical power splitter with s-bend waveguide and study on the Variation of Transmitted power with Variation of Components Width

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Abstract

This paper aims to investigate the device based on symmetric Y-branch comprising of S-bend waveguide. Initially, a symmetric Y-junction based 1×2 optical power splitter is designed, which can deliver the best result in simulated performance. The design is, however, not technology-compatible to be fabricated in LiTaO3, and therefore, the design is modified by incorporating a finite gap at the splitting junction, instead of zero-gap. 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.

Keywords*: 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 however not technology compatible to be fabricated in LiTaO3 and therefore the design is modified by incorporating a finite gap at the splitting junction, instead of zerogap. This gap 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

Fig:1 illustrates the top view of the Y-branch optical 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.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. 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. 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.

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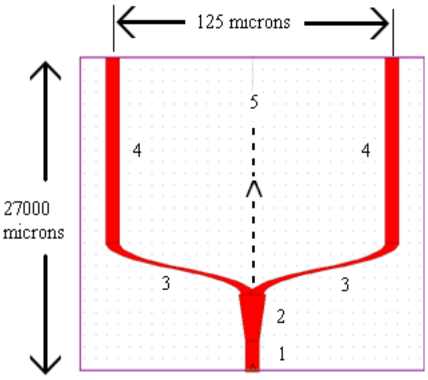

1. Straight input waveguide
2. Linearly tapered waveguide
3. S-bend waveguides
4. Straight output waveguide
5. Direction of propagation

Fig1: The figure shown is a Y-branch power splitter (Top view)which is 27000µm in height and 125 µm in width from center to center of the split wave guides. This is designed by R-Soft CAD tool and simulated by Bean-Prop.

3. Simulation and Its Results

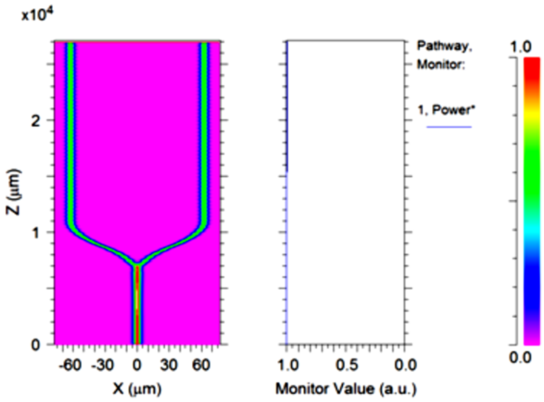

Fig 2: Simulation of optical signal in power splitter

In the First fig the transmission of power is shown initially with Red Colour where the input power is 1w and in the seconf figure the path monitor value, the output transmitted power is shown as Blue line on the scale indicating the power to be approximately 1w indicating very less loss.

Mode profiles

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 colour 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 Lithum Tantalate considered are no=2.178 and ne=2.180 The index difference is maintained to be Δn= 0.002.

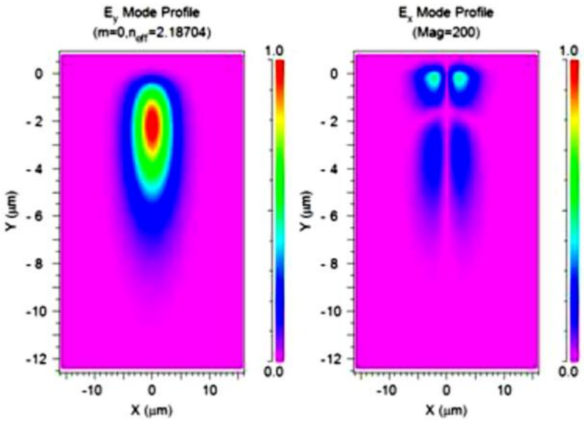

Fig3: Simulation of the Mode profile and effective refractive index across the width of the optical splitter at the wavelength 1550nm, Width 6µm.

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 formulas

IL = 10log10 (P1/*P2*) dB

Where **IL** is the Insertion loss of an optical splitter and is usually measured in decibels (dB\mm).
P1 is the given input power (1 Watt) and
P2 is the output transmitted power in Watts.
α = *IL*/L dB /mm
Where **α** is the attenuation coefficient measured in decibels.
IL is the insertion loss in dB/mm. **L** is the length of the device (27000µm).

Variation of Components Width

The width is varied in the range 3 µm to 6 µm in the steps of 1 µm. The maximum transmitted power, p_2=0.99watts for the input power, p_1=1Watt is obtained at the width 6 µm with the other parameters kept constant i.e. branching angle 2θ=0.6degree, wavelength=1550nm, index difference Δn =0.002.

Table.1 Variation of transmitted power with width

S.No.	Width W (µm)	Transmitted power P_2 (watts)	Power loss (dB)	Attenuation coefficient α (dB*10^{-5})
1	3	0.93557	0.2892	1.0712
2	4	0.96409	0.1588	0.5882
3	5	0.98568	0.0626	0.232
4	6	0.99105	0.0390	0.144

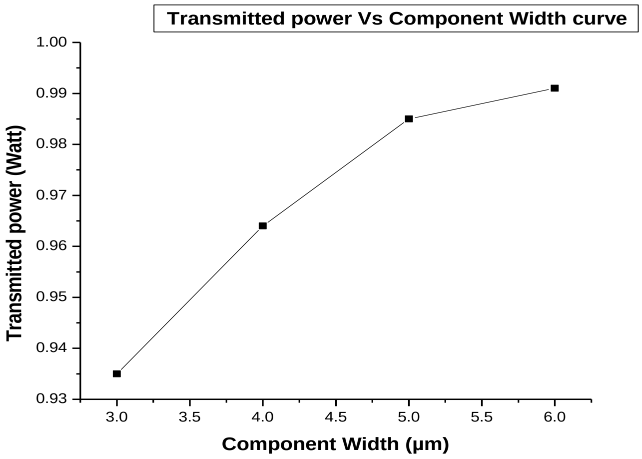

Fig 4 Transmitted power V/S component width

Conclusions

Photonic devices lie at the heart of the communications revolution, and have become a large and important part of the electronic engineering field. Photonics is discipline concerning the control of light, or photons, for useful applications, much as electronics has to do with electrons. 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 different branch angles is studied. The insertion loss and the attenuation coefficient is calculated using the above mentioned formulae. The graphs between Transmitted power and branching angle are plotted. It is found that this optical device is giving maximum output at wavelength 1550nm, branching angle 0.6degrees. 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.

Acknowledgment

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