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Optical communication modulator at 1.33μm for integrated optics applications

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Abstracts

Voltage tunable optical communication modulators using optical filter are now the most important and advanced integrated devices in the field of integrated optics. The modulator with central wavelength 1.33um is studied which works on wide range of wavelength. The tunable wavelength can be achieved by changing voltage across electrodes. the design of voltage tunable optical modulator using asymmetric directional coupler filter modulator with strip of waveguide made up of Titanium in diffused in Lithium Niobate for various fabrication parameters for central wavelength 1.33mm is studied. Matrix method, which is faster, is used for computation of effective index. Based on this method the critical coupling length is investigated. The work focused on studies of the directional coupler filter modulator at wavelength 1.33mm .The response with maximum transfer efficiency. the effectiveness of device by reducing coupling length and device length is studied.

Keywords

voltage tunable filter, 1.33μm, Ti:$LiNbO_3$ waveguides

Summary

1. Introduction

In the recent past there has been a rapidly growing applications in the field of integrated optics and various optical waveguids designs. The broad interest of these research and experiments has been in field of microwaves applications and cable T.V. networks. In present era, the requirements of telecommunication services and demand for higher bandwidth have increased radically. Lithium Niobate ($LiNbO_3$) external modulator provides both required bandwidth and much-needed means of decreasing the effects dispersion. Tunable linearized external modulators can provide very low modulation distortion. Advances in $LiNbO_3$ modulator device technology have enable stable operation over a wide range temperature, very low bias voltage, and interference free devices. The device size could be smaller offering easy tunability, simple fabrication process and higher signal to noise ratio (S/N) ratio.

2.1 Principle of Operation

An asymmetric directional coupler used in a fabrication of filter consists of two adjacent waveguides arranged such that the tail of field guided by one waveguide overlaps the other waveguides as shown in Fig.1. The coupling between two waveguides occurs due to such overlaps. When the light signal with power P1 is launched into waveguide 1 it will get coupled to waveguide 2 over the coupling region.The coupling length lc is given by [2,8] , where βe is propagation constant for even mode, βo is propagation constant for odd mode.

When an asymmetric coupler is used a propagation constant difference (δ) is involved which is given by [1]. ,where β1 and β2 are Propagation constants of waveguide1and 2 respectively.

It is also known that for the complete power transfer, parameter δ should be equal to zero, i.e. maximum power gets dispersed from waveguide 1 to waveguide 2. If coupler length L is equal to an odd multiple of lc (lc =2 π/k), then coupling takes place in region of 0 to lc in which the even and odd normal modes can propagate with propagation constants β1and β2. The guided modes incident from waveguide 1 excites the even and

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odd modes in phase with the same amplitude at z = 0, where z is the point between 0 and lc, the resultant electric field distribution of even and odd modes coincide with the electric field distribution of guided modes in waveguide 2, thereby all power is coupled to waveguide 2. By applying voltage to the electrodes the electrical tuning at centre wavelength occurs. This is due to the change in waveguide refractive indices.

2.2 Ti-Concentration and Refractive Index Profile

A strip of Ti film deposited across Z-axis of Lithium niobate substrate and for such fabrication the diffusion equation in X-Z plane can be written. in which external perturbations are neglected and C (x,z,t) is Ti concentration and Dx and Dz are diffusion co-efficient along the X and Z direction respectively.

An undoped crystal of Lithium niobate is transparent and birefringent. The refractive indices of ordinary (no) and extraordinary beams (ne) can be obtained using the modified Sellmeier equations [5],

Modified expression of Ti concentration obtained. in which dz and dx are the diffusion lengths along z and x axis respectively. Co is initial Ti concentration.

where g(x) is error function

Design overview

Coupling Length

Critical coupling length (lc) is minimum length of a coupled waveguides, which is necessary for complete transfer of power. Critical coupling length depends upon the thickness and width of Ti strips, gap between the Ti strips in coupled region, diffusion parameters and wavelength. For the computation of propagation constants and lc, matrix method is implemented. The wave excitation efficiency (η) in a waveguide is computed as a function of β by varying incident angle from θc to 90.

Discussion:

The 1-D effective index profile [neff(x)] of waveguide for TMo mode is calculated for various values of x and plotted for center wavelength 1.33 µm. The effective refractive index is observed to be maximum at at wavelength. These values are essential for the computation of the relation between centre wavelength & tuning voltage.The coupling length is found 2.2964 mm for L=2.31 cm and λ=1.33 µm .

The response for zero applied voltage is computed and plotted The responses show the relation between wavelength and phase match efficiency. It is observed that the efficiency is maximum at the designed wavelengths. The relation between filter central wavelength and applied voltage is computed for both wavelengths. It is observed that the relation is linear. This further indicates that the said device offers an excellent tunability over a wide range of voltages between –5 to+5 V. The linear relationship is obtained between bandwidth and various tuning voltages. The bandwidth found to be 39.651 nm for L = 2.31 cm, at 1.33µm.