New All-optical Wavelength Auto-router Based on Multibranch Waveguides

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Abstract

A new optical device for wavelength auto-router was proposed. Such a structure is useful in the integrated-optic for optical operation and data communication. We use the finite-difference beam propagation method to investigate the phenomenon of the proposed numerical model.

Keywords: wavelength router, *multimode waveguide, planar waveguide*

1. Introduction

Multibranch waveguides are important components in the applications of integrated optics. The multibranch waveguides can be designed to operate as switches, power combiners, power dividers, and multipliers [1-3]. In the future, the multibranch waveguides promise to be a key component for the subscriber loop of optical fiber communication systems.

In this paper, we proposed a new wavelength router that is designed by a string of multibranch waveguide. This device can be used to split the wavelength of 1550*nm* spectral region. It is well-known that multi-wavelengths are at the basis of WDM networks. WDM is one promising approach that can be used to exploit the huge bandwidth of optical fiber. By utilizing WDM in optical fiber networks, the ultra-high-speed and ultra-high-capacity optical communication systems can be achieved by dividing the optical fiber bandwidth into several non-overlapping wavelength bands, each of which may be accessed at peak electronic rates by an end user [4]. It will have a grate contribution in optical communication.

2. Analysis

The operation is based on the mode evolution in multichannel branching waveguides [5-6]. The structure of the proposed wavelength router by using a multibranch waveguide is shown in Fig.1. All branching angles θ are equal. Each guiding channel is characterized by a given width $W_n = W_0 - (n-1)\Delta W$ (n=1,2,3,…,10) and the sum of each guiding channel of the width $W = \sum_{n=1}^{m} W_n$. Where m is the branch number (in this case, m = 10), W_0 is the width of the largest channel waveguide, ΔW is the channel-width difference. For each output channel to be in single-mode condition the following equation must be satisfied:

$$m(m-1)\Delta W < 2W_0 < \frac{\lambda_f}{\left(n_f^2 - n_c^2\right)^{\frac{1}{2}}} \qquad (1)$$

λ_f is the input wavelength, and n_f and n_c are the indices of refraction in the channel and in the surrounding regions, respectively. According to inequality (1), there is a restriction on width W_0 and the channel-width difference ΔW .

3. Numerical results

By using the finite difference beam propagation method [7] we can simulate the propagation phenomena of the signal beam propagating along the structure. The numerical data have been calculated with the values: the guiding channel refractive index $n_f = 1.57$, background refractive index $n_c = 1.55$, branching angle $\theta = 0.01°$, the width of multimode waveguide $W = 28.48\mu m$, $W_0 = 3.1\mu m$, $\Delta W = 0.056\mu m$, $L_1 = L_3 = 45mm$, and. $L_2 = 5mm$. We show a numerical result of a all-optical wavelength router with the input wavelength in 1546nm-1555nm spectral region. Because for the conventional single-mode optical fiber, when the wavelength of the input light wave in 1550*nm* spectral region, the dispersion is near zero and the transmission loss is very low. The numerical results are shown in Figs. 2. Fig. 2 shows the evolutions of the input signal beams propagating along the structure with the wavelength of the input signal beams in 1546nm-1555nm spectral region. We superimpose Fig. 2(a)-(j) as shown in Fig. 3. Fig. 4 shows the transmission efficiency P_0/Pi (Pi the input signal power, P_0 the output signal power) of the input signal beam propagating throughout the output section. The numerical results show that the transmission efficiency is very high, more than 80%. When the input wavelength among the input guiding channel is on, the output signal beams will be switched from one output guide to another. The output beam is relative to the input waveguide and no relationship with the length of the central straight waveguide.

4. Conclusion

In this chapter, we proposed a multibranch wavelength router. The well-established finite-difference beam propagation method was used to simulate the proposed device. The numerical results show that the proposed device really can achieve a wavelength router. It would be a potential key component in the applications of ultra-high-speed and ultra-high-capacity optical communications and optical data processing systems.

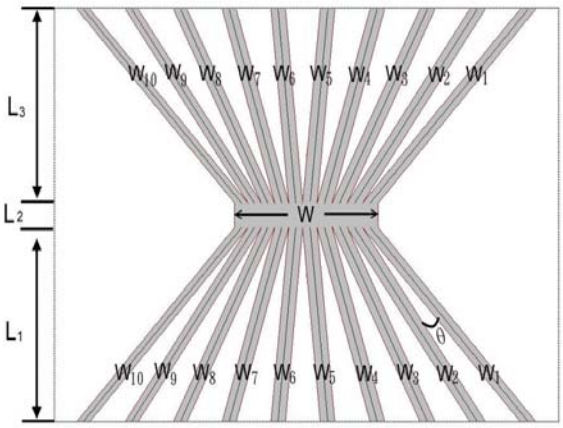
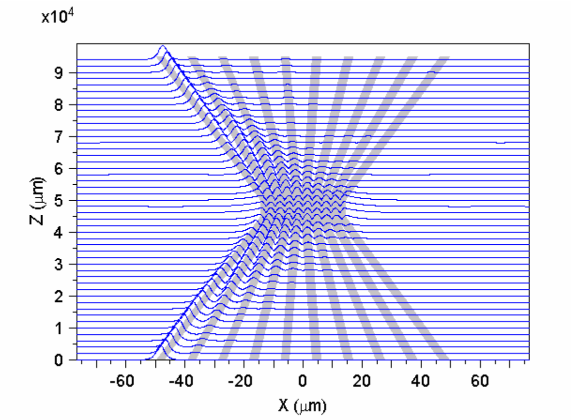
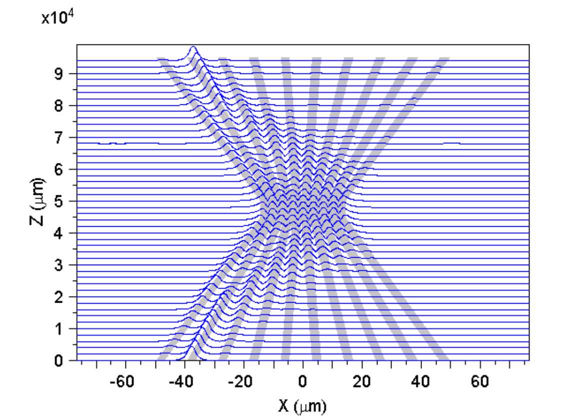


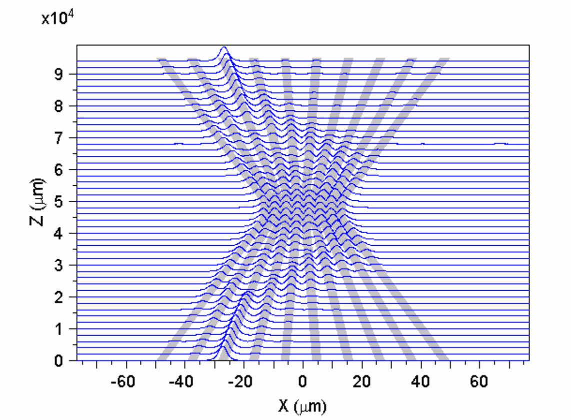
Fig. 1 The proposed multibranch waveguide structure of the all-optical wavelength auto-router.



(a)



(b)



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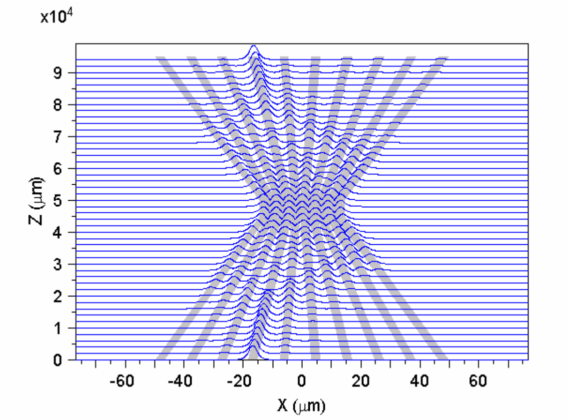
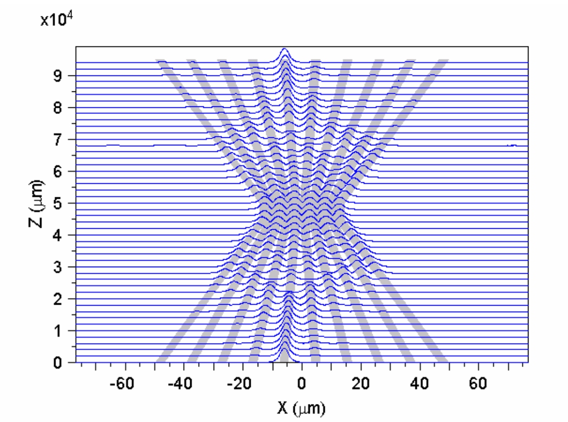
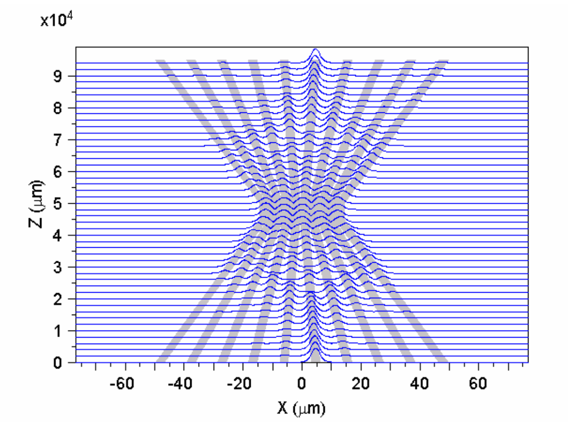
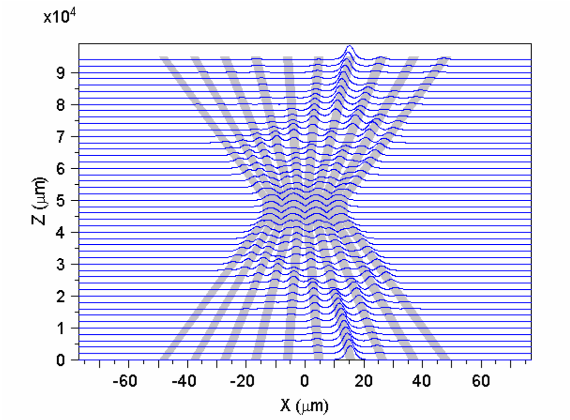

x10^4
Z (μm)
X (μm)
-60 -40 -20 0 20 40 60
(d)


x10^4
Z (μm)
X (μm)
-60 -40 -20 0 20 40 60
(e)


x10^4
Z (μm)
X (μm)
-60 -40 -20 0 20 40 60
(f)


x10^4
Z (μm)
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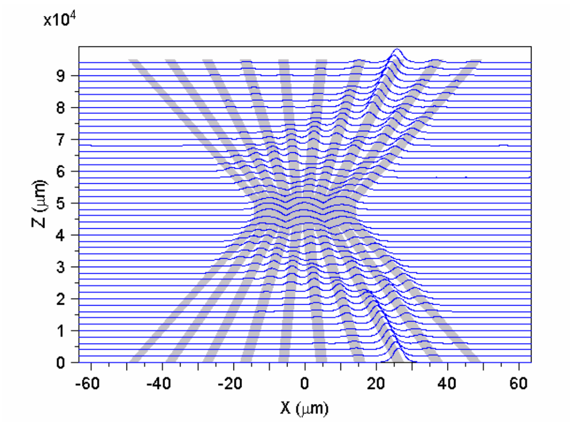
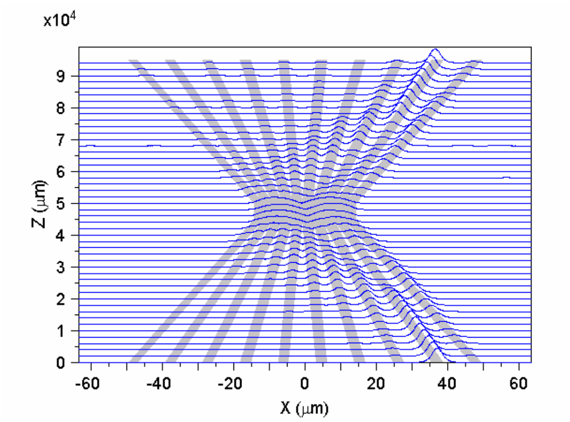
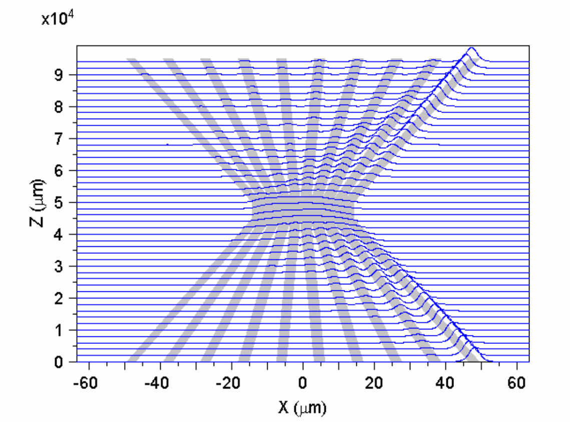
-60 -40 -20 0 20 40 60
(g)


x10^4
Z (μm)
X (μm)
-60 -40 -20 0 20 40 60
(h)


x10^4
Z (μm)
X (μm)
-60 -40 -20 0 20 40 60
(i)



(j)

Fig. 2 The signal beam of the output section with the wavelength of the input signal beams in (a) 1546*nm*, (b) 1547*nm*, (c) 1548*nm*, (d) 1549*nm*, (e) 1550*nm*, (f) 1551*nm* (g) 1552*nm*, (h) 1553*nm*, (i) 1554*nm*, (j) 1555*nm*.

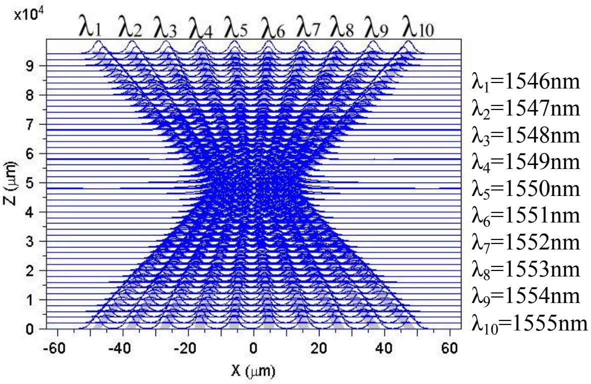


Fig. 3 To superimpose Fig. 2(a)-(j).

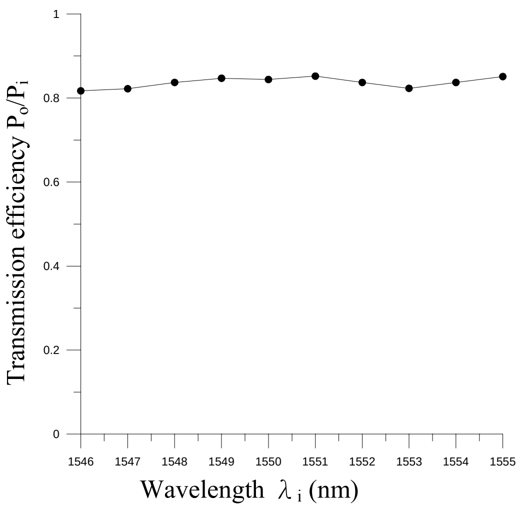


Fig. 4 The efficiency of the input signal as a function of the input wavelength λ_i.

5. References

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