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Wavelength Switching Using GaInAs/InP MQW Variable Index Arrayed Waveguides by Thermo-Optic Effect

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Abstract

We have successfully demonstrated the wavelength switching in the straight arrayed waveguide with linearly varying refractive index distribution by changing the refractive index using thermo-optic effect. We have obtained the wavelength demultiplexing and its changing of the output ports by refractive index change in the waveguide.

Introduction

In WDM networks, key components are the wavelength multi-/demultiplexers, which combine/separate wavelength channels. Various kind of demultiplexing principles have been proposed and already commercially available, such as arrayed-waveguide gratings (AWG). In the latest paper, a novel wavelength demultiplexer using a GaInAs/InP multiple quantum well (MQW) arrayed waveguide has been proposed in which refractive index varies linearly across the array [1,2]. The conventional AWGs are designed so that phase differences between adjacent waveguides are obtained by gradually varying waveguide length. In the proposed design, however, phase differences between adjacent waveguides are achieved by varying the waveguide thickness which is the refractive indices of the waveguides. Therefore, it is possible to be realized a straight waveguide type wavelength demultiplexer [2,5]. Furthermore, the device could be applied to wavelength switching since the refractive indices of the waveguides in the array can be controlled dynamically by QCSE or TO effect. In this report, we show the successful wavelength switching in the arrayed waveguides with linearly varying refractive index distribution by controlling the refractive index using TO effect.

Device Structure

Fig. 1 shows the schematic design of the wavelength switch. The arrayed waveguide region was fabricated by selective metal-organic vapor phase epitaxy (MOVPE) growth using the asymmetric SiO_2 mask pattern on both sides of the array [3,4].

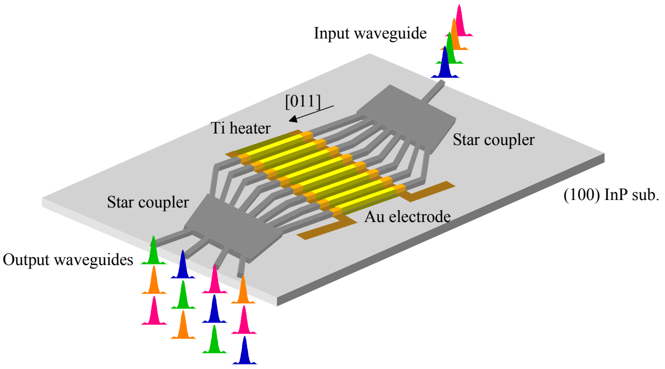


Fig. 1. Schematic design of the wavelength demultiplexer using arrayed waveguides with linearly varying refractive index distribution

The number of arrayed waveguides was *N*=16, waveguide width *w*=3 μm and waveguide spacing was narrowed from *d*=3 μm to 2 μm toward the star coupler, and the length of arrayed waveguides were 10 mm. Four output waveguides spaced by 6 μm were located at the end of output star coupler. In the designed star coupler, incident lights are distributed to array with equal phase front and output lights from array are focused to the output waveguides based on Rowland circle geometry. All the arrayed waveguide between input and output star couplers has equal length though the straight arrayed waveguides and the star couplers were joined with curved waveguides. Additionally, the positions of the input and output star couplers, which are not placed on straight axis, are effective to reduce the recoupling of the scattered light. TO control the refractive index in the waveguides, Ti/Au electrode was placed on the center of the arrayed waveguide region with 1000 μm length.

Wavelength Switching

The successful wavelength switching was demonstrated in the device mentioned above. Fig. 2 shows the three port switching characteristics of the λ=1540 nm wavelength light which is the dependence of output intensity on electric power. When there was no input electric power, the light was outputted from Port 2. By increasing the input electric power, the output port was changed to Port 3 and Port 4. The extinction ratio was 8.7 dB at Port 2, 6.2 dB at Port 3, and 17.3 dB at Port 4. From these results, the estimated refractive index change in the waveguide was 0.13 % for one-port switching.

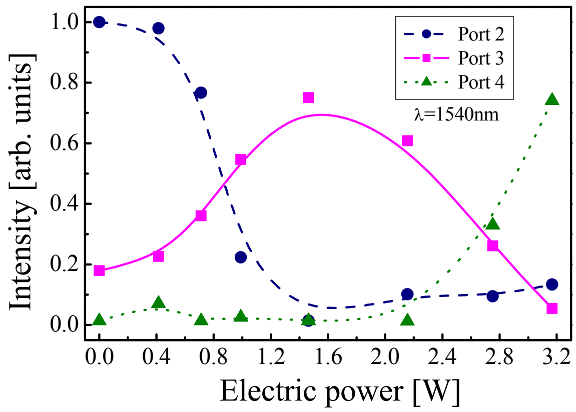
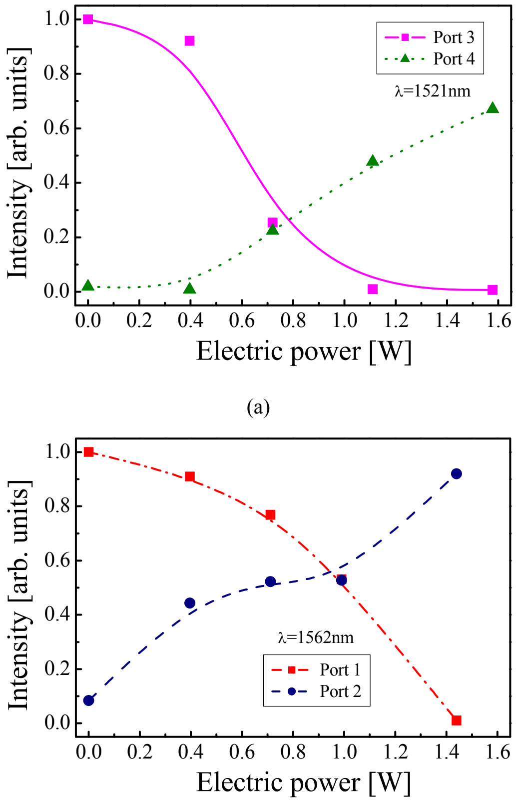


Fig. 2. Three port switching characteristics of the λ=1540 nm wavelength light. The dependence of output intensity on electric power.

Fig. 3 show the switching characteristics of other wavelength light of (a) λ=1521 nm and (b) λ=1562 nm. Without the electric power, the 1521 nm and 1562 nm wavelength light was coupled to Port 3 and Port 1, respectively. When the electric power was 1.46 W, the output port of these wavelength lights were changed to Port 4, and Port 2. From these results, we have successfully obtained the wavelength demultiplexing and output port switching by controlling the refractive index change in the arrayed waveguides. The electric power can be reduced by optimizing the thickness of Ti heater and the SiO_2.

These results are an actual proof that the proposed design is suitable for the application to wavelength switching. Further development of electric-field control of refractive index would also be expected to yield high speed wavelength switching.



(a)

(b)

Fig.3. Switching characteristics of other wavelength light of (a) λ=1521 nm and (b) λ=1562 nm

Conclusion

We have demonstrated the wavelength switching in the arrayed waveguide with linearly varying refractive index distribution. We have obtained the three port switching by the refractive index change using the thermo-optic effect.

References

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