Design, Fabrication, and Testing of Single-Side Alignment of 16×0.8nm Arrayed-Waveguide Grating*

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Abstract: A novel design of 100GHz-spaced 16channel arrayed-waveguide grating (AWG) based on silica-on-silicon chip is reported. AWG is achieved by adding a Y-branch to the AWG and arranging the input/output channel in a neat row, so the whole configuration can be aligned and packaged using only one fiber-array. This configuration can decrease the device's size, enlarge the minimum radius of curvature, save time on polishing and alignment, and reduce the chip's fabrication cost.

Key words: optical planar waveguide; phased arrays; wavelength division multiplexing
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1 Introduction

All-optical wavelength division multiplexing (WDM) networks are very attractive because of their capability of processing broadband optical signals directly instead of converting them to electronic signals, which overcomes the electrical bandwidth limitations. In addition, WDM networks based on wavelength routing are beneficial for wide bandwidth multiple applications. This is made possible by the introduction of wavelength routers[1~3], broadly tunable lasers[4], wavelength converters, etc.

The polishing, alignment, and packaging play an important role in fabrication of AWG device. To predigest these processes, we report a silica-based single-side alignment 16channel AWG demultiplexer, which is achieved by adding a Y-branch to the AWG and arranging the input/output channel in a neat row, so that the whole configuration could be aligned and packaged using one fiber-array. This configuration can decrease the device's size, enlarge the minimum radius of curvature, save time on polishing and alignment, and reduce the chip's fabrication cost.

2 AWG configuration

The design parameters of our AWG are listed in Table 1. The channel spacing and the number of channels are 100GHz and 16, respectively, In order to achieve these values, the path length difference between the adjacent arrayed waveguides, 128.418μm, is calculated. The number of arrayed waveguides is chosen to be 85. The refractive index difference is 0.75%, and the minimum radius of curvature is 6mm.

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Table 1　Design parameters of 16 ×0. 8nm AWG

Number of channels	16
Central wavelength/μm	1. 5525
Channel spacing/ nm	0. 8(100 GHz)
Core size/μm ×μm	6 ×6
Free spectral range/ nm	15. 46
Diffraction order	120
FPR/μm	9419. 723
Path length difference Δ*L* /μm	128. 418
Number of arrayed waveguides	85

Figure 1(a) shows the AWG waveguide pattern with the parameters listed in Table 1 ,with which we designed AWG with the conventional configuration. It needs to be polished on both opposite sides and needs two fiber-array to align and package. However ,as seen in Fig. 1(b) ,we use a novel method ,by adding a Y-branch waveguide to the AWG and arranging the input/ output channel in a neat row ,so that the device only needs to be polished in one side and the whole configuration could be aligned and packaged using one fiber-array. The process time of polishing and alignment can be decreased obviously.

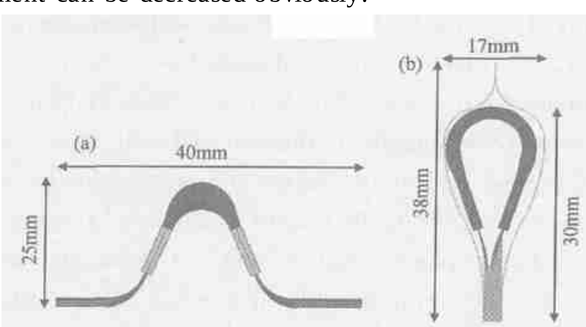

Fig. 1　Layout of AWG designed with conventional (a) and our (b) configurations

Figure 2 shows the detail of the AWG's input and output waveguides arrangement. The space between each waveguide is invariably 127μm to fit the standard fiber-array.

3　Measurement and results

The transmission spectrum of the silica-based AWG is measured by the EDFA light source and the optical spectrum analyzer. The end-faces of the single-side AWG chip and the standard fiber-array are polished 90°.

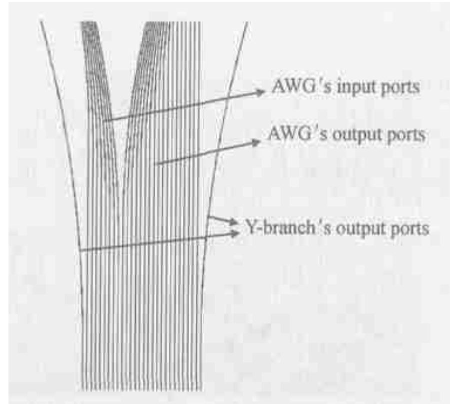

Fig. 2　Detail of the AWG's input/ output waveguide arrangement

First ,a single mode fiber is accurately aligned to the Y-branch. Then , the first channel and the last channel of the fiber-array are aligned to the end-face of the AWG device. When the dual-channel optical detector shows that the two waveguides of the Y-branch are already accurately aligned to the fiber-array and the total intensity reaches the maximum ,the alignment process is finished. Then we can remove the single mode fiber ,connect the EDFA light source to the AWG's input port ,and test its characteristic.

The transmission spectrum against wavelength in the 1550nm window is shown in Fig. 3 ,where input ports # 1 are used for the measurement. The measured 3dB bandwidth is 0. 5nm. The output power uniformity over the 16 output channels is less than 2dB. The insertion loss of the center output waveguide is 16. 5dB ,which includes the 12dB material absorb loss. Figure 4 shows the measured pass wavelengths of the AWG multiplexer. The slope is 0. 79078nm/ channel. It is almost the same with the designed spacing of 0. 8nm.

Figure 5 shows the measured spectrum from the # 6 output port with the light-source inputted from the different input ports. The profile and the amplitude of each peak were same ,which shows the AWG chip has been well aligned to the fiber-array.

Table 2 shows the comparison between design

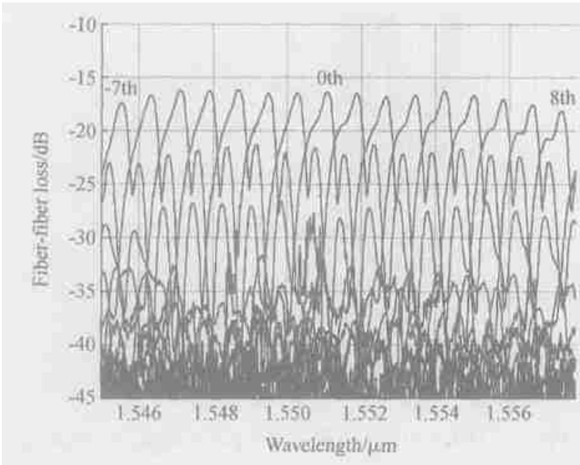

Fig. 3 Transmission spectrum of 16 channels

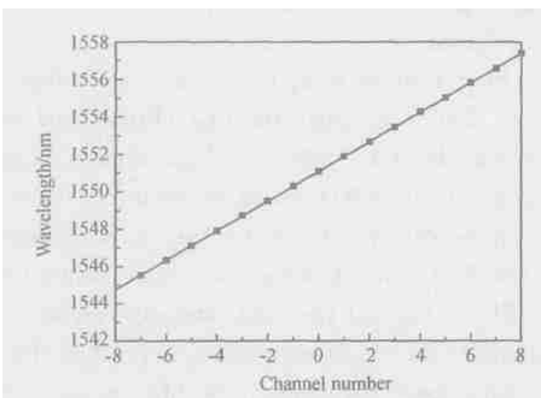

Fig. 4 Measured pass wavelengths of the multiplexer output channels The slope is 0. 79078nm/ channel.

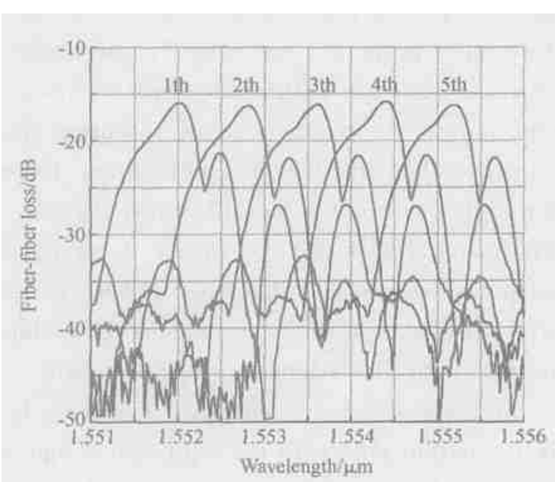

Fig. 5 Measured spectrum from the # 6 output port with the light-source inputted from the different input ports

and measurement. There is an obvious excursion between the measured value and the designed one in the items of the insertion loss and the cross talk. The reason contains in the following factors:

(1) The reason why the insertion loss increases to 16. 5dB is mainly that the material absorb loss. Figure 6 shows the absorb loss spectra of the silica-based material. The absorb loss measured by the Metricon coupler is 1. 98dB/ cm ,while the material transmission loss by calculation is about 12dB. If we use the same kind of silica-based chip from overseas ,the absorb loss will be decreased to 0. 04dB/ cm , so the device 's insertion loss will be lowered to about 5dB including the coupling loss.

(2) The loss is related to the waveguide profile by the RIE etching process.

(3) To improve the cross talk of the AWG device ,there are three aspects to be considered seriously: First ,the phase error in the arrayed-waveguide. If there is a length undulation in the arrayed-waveguide ,the cross talk will increase to - 20dB ,when the standard deviation of the measurement arrayed-waveguide length is up to 10nm. Second ,the quality of the material will influence the cross talk of the device. Theoretic calculation shows that when the variety of the core 's refractive index is up to 1×10^{-4} (standard deviation) ,the cross talk of the device will increase to - 22dB. Third ,the core size of the waveguide will influence the cross talk. For the random error in the fabrication of the mask and the etching process ,when the error is big enough ,the performance of the AWG device will decline rapidly.

Table 2 Comparison between design and measurement

	Calculation	Measurement
Channel spacing/ nm	0. 8	0. 79078
Central wavelength/ μm	1. 5525	1. 55266
Insertion loss/ dB	12(1. 98dB/ cm)	16. 5～18. 5
Cross talk/ dB	< - 45	- 5
3dB bandwidth/ nm	0. 3	0. 5
IS uniformity/ dB	2	2

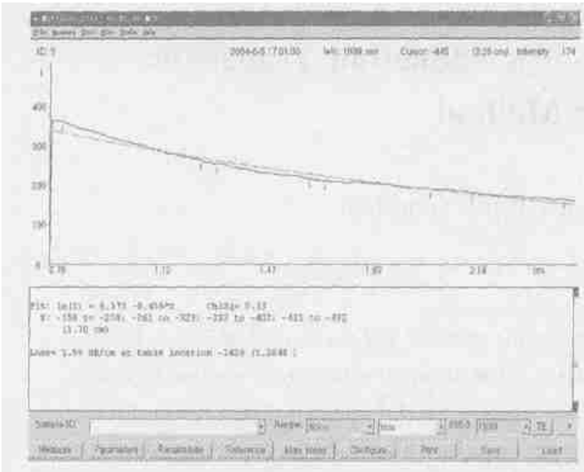

Fig. 6　Absorb loss measured by Metricon coupler

4 Conclusion

We have fabricated a single-side alignment silica-based 100 GHz-spaced 16channel AWG multi/ demultiplexer by adding a Y-branch to the AWG and arranging the input/ output channel in a neat row , so that the device only need to be polished in one side and the whole configuration could be aligned and packaged using one fiber-array. This configuration can decrease the device 's size , enlarge the minimum radius of curvature , save time on polishing and alignment ,and reduce the chip 's fabrication cost. The insertion loss is 16. 5dB including the material absorbing loss 12dB. The IS uniformity is less than 2dB. Improving the quality of material and the precision of process will further enhance the performance of the AWG device.

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单侧耦合 16 ×0. 8nm 阵列波导光栅的设计、制备及测试 *

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摘要: 介绍了一种新型 16 通道、100 GHz 通道间隔的硅基二氧化硅单侧耦合阵列波导光栅 (AWG) . 通过增加一个 Y 分支波导结构 ,并且将 AWG 的输入、输出波导等间距整齐排列 ,实现了仅用一个光纤阵列进行 AWG 器件的耦合封装. 这种 AWG 的结构设计可以有效地减小器件尺寸 ,增加波导结构的弯曲半径 ,减少器件抛光及耦合时间 ,并降低器件成本.

关键词: 光波导; 相位阵列; 波分复用

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