Compact 16×16 channels Routers based on Silicon-On-Insulator AWGs.

S. Pathak,[1] M. Vanslembrouck, P. Dumon, D. Van Thourhout, and W. Bogaerts.

[1] Department of Information Technology, Ghent University-IMEC, 9000 Ghent,Belgium

We demonstrate an ultra small 16×16 channels 400 GHz wavelength Router on SOI. Insertion loss from center channel input to center channel output, non-uniformity over outer most output channel to center channel output and non-uniformity over outer most input channel to center channel input are $-3.00dB$, $2.09dB$ and $1.79dB$ respectively. Crosstalk of the device is $20dB$. The device size is only $475 \times 330\mu m^2$.

Introduction

Arrayed Waveguide Gratings(AWG) are one of the vital components in WDM systems, which have high commercial interest because of high transmission capacity and more flexibility in the telecommunication network. AWG works as both wavelength division multiplexer and demultiplexer. With an appropriate combination of two free propagation region (FPR) and an array of waveguides with a linear increment of length makes an AWG. Dragone in 1991 extended the concept of AWG from $1 \times N$ channels to $N \times N$ channels device, which is popular as a wavelength routers [1] [2]. Figure 1 shows a schematic diagram of a 16×16 channels 400 *GHz* wavelength Routers.

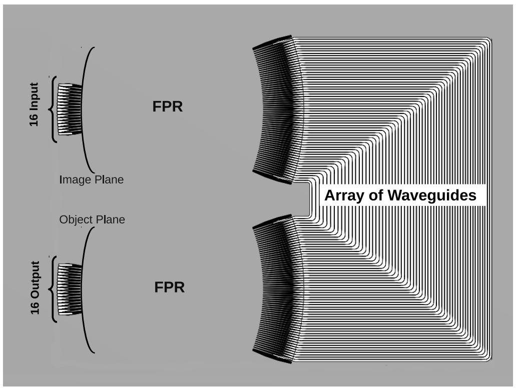

Figure 1: Schematic diagram of a 16×16 channels 400 *GHz* wavelength Routers.

In SOI due to the sharp bend radius[3] and the high group index of the waveguides makes the router very compact but sensitive to phase noise. So demonstration of such a device in SOI platform is difficult.

Working Principle

The operation of the regular AWG is described as follows. A light beam propagating through the waveguide enters into the first star-coupler and diverges. This diverging light beam is coupled in the arrayed waveguides and propagates to the second star-coupler. The optical path length difference between two successive waveguides of the array waveguides is $\Delta L = m \cdot \frac{\lambda_c}{N_g}$, where m is the order of the phased array, λ_c is the center wavelength of the AWG, and N_g is the group index of the waveguide. For this center wavelength the fields from the array waveguides will reach to the second star-coupler with equal phase and the interference will reproduce the field distribution of the object plane at the image plane. With perfect imaging, the field distribution at image plane will the equal amplitude and phase of the field distribution of the object plane [4]. The phase difference in the array waveguides changes with wavelength because of the length difference and the wavelength-dependence of the propagation constant. This phase delay which will introduce a lateral shift of the field profile in the object plane. Thus the spectral response will be determined by the overlap of the field profile at object plane, with the mode at the image plane combined with the wavelength-dependent shift of the image.

To discuss the wavelength responses of a Router, we consider a 5×5 channels for simplicity. The convention of the channel numbering is shown in Figure 2.

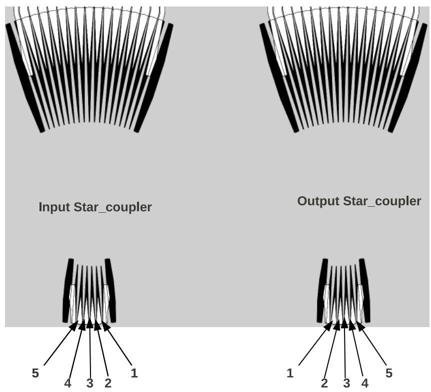

Figure 2: Convention of the channel numbering.

		Output Channels				
Input Channels	No	1	2	3	4	5
	1	λ_{-1}	λ_{-2}	λ_{+2}	λ_{+1}	λ_c
	2	λ_{-2}	λ_{+2}	λ_{+1}	λ_c	λ_{-1}
	3	λ_{+2}	λ_{+1}	λ_c	λ_{-1}	λ_{-2}
	4	λ_{+1}	λ_c	λ_{-1}	λ_{-2}	λ_{+2}
	5	λ_c	λ_{-1}	λ_{-2}	λ_{+2}	λ_{+1}

Table 1: Wavelength responses of a 5×5 channels Router. 'Blue' boxes represent the wavelengths of m order, 'Green' boxes represent the wavelengths of $m+1$ order, 'Yellow' boxes represent the wavelengths of $m-1$ order.

Table 1 shows the wavelength responses of a 5×5 channels Router. As from the table we can see when light enters from the center channel input, the center wavelength (λ_c) will come out from the center channel out and when we change the input channel the wavelength response at the output channels makes a cyclic rotation. At the output channels first and last channel will experience approximately same excess loss from the center input channel. As the router will work in reverse way also at a given output channel the spectral response will experience approximately same excess loss for first and last input channel from the center input channel. In Table 1 at position T_{11} and T_{55} will have the highest loss and T_{33} will have the lowest loss.

Results

Figure 3 shows spectral response of 16×16 Router of $400GHz$ for 1^{st} input. The center channel loss, non-uniformity and cross-talk are $-5.09dB$, $2.63dB$, and $19dB$ respectively. Figure 4 shows spectral response of 16×16 Router of $400GHz$ for 8^{th} input. The center

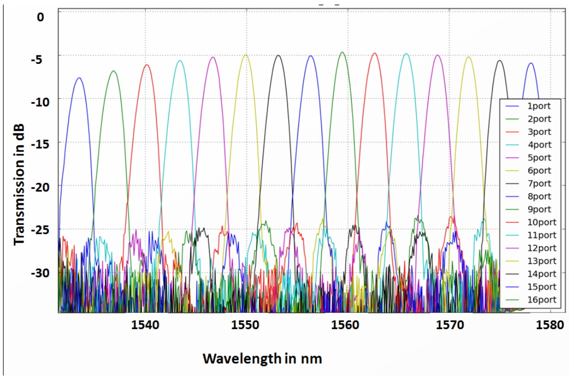

Figure 3: Spectral response of 16×16 Router of $400GHz$ for 1^{st} input.

channel loss, non-uniformity and cross-talk are $-3.00dB$, $-1.79dB$, and $20dB$ respectively.

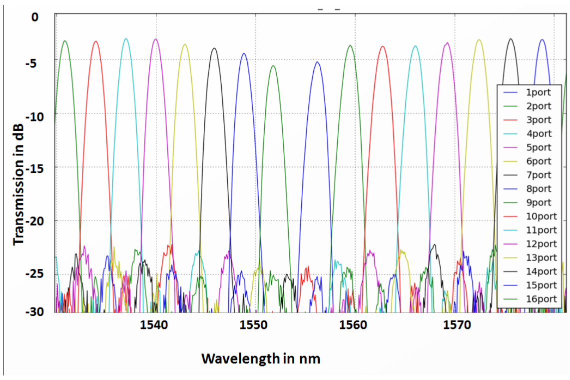

Figure 4: Spectral response of 16×16 Router of $400GHz$ for 8^{th} Input

Figure 5 shows entire spectral response of 16×16 Router of $400GHz$. The length of the bar of each point is equal to the $3dB$ bandwidth of each channel.The color of every points indicates the insertion loss of each channel. Ideally all the points should make a perfect align 16×16 matrix but for this device the matrix is diagonally shifted towards the lower wavelength. This imperfect cyclic behavior can be explained by the mismatch between the dispersion accounts for the design with reality.

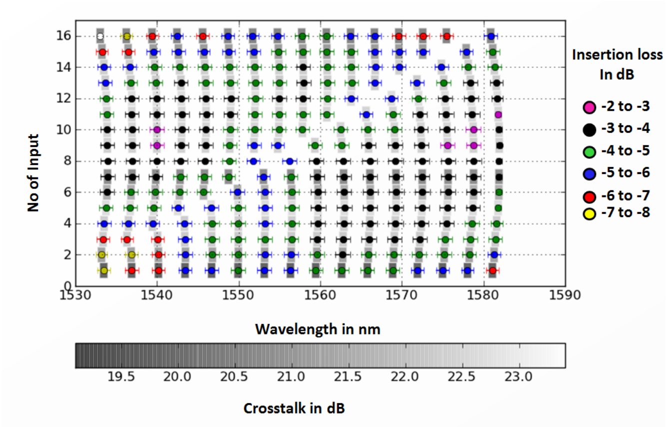

Figure 5: Spectral response of 16×16 Router of $400GHz$ for all Input

Conclusion

An ultra compact 16×16 Router of $400GHz$ on silicon-on-insulator(SOI) has been reported. The device size is $475 \times 330\mu m^2$. Insertion loss from center channel input to center channel output, non-uniformity over outer most output channel to center channel output and non-uniformity over outer most input channel to center channel input are $-3.00dB$, $2.09dB$ and $1.79dB$ respectively. For all inputs, the center channel crosstalk are between $19dB$ to $21dB$.

References

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