MEMS-Actuated 8x8 Silicon Photonic Wavelength-Selective Switches with 8 Wavelength Channels

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Abstract: We report on a fully integrated 8x8 silicon photonic MEMS wavelength-selective switch with 8 wavelength channels on a 9.7mm x 6.7mm chip. Total on-chip loss including switches and echelle grating mux/demux is 13.3 dB. © 2018 The Author(s)
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1. Introduction

In recent years, high-radix silicon photonic switches have been intensively explored to reduce latency, cost, and energy consumption of datacenter networks. High-port count silicon photonic switches, up to 64x64, have been demonstrated [1,2]. Wavelength-division-multiplexing (WDM) can further increase the capacity and enable routing of individual wavelengths in next-generation datacenter networks. Previously, a 4x4 WDM switch with 4-wavelength channels has been reported using SOA (semiconductor optical amplifier)-based wavelength selective switching on InP platform [3]. On silicon photonics platform, a 1x2 wavelength selective switch (WSS) handling 20-wavelength channels with fold-back arrayed waveguide gratings (AWGs) [4], and an 8x8 WDM switch handling 2-wavelength channels with feedback-controlled ring resonators [5] have been demonstrated.

In this paper, we report on an 8x8 silicon photonic WDM switch with 8-wavelength channels. To the best of our knowledge, this is the largest channel capacity (64 channels) integrated WDM switch ever reported. 8 subarrays of 8x8 digital silicon photonic MEMS switches are monolithically integrated with 16 echelle grating multiplexers/demultiplexers. This wavelength selective switch inherits the fundamental advantages of our silicon photonic MEMS space switch, namely low optical insertion loss, low crosstalk, low power consumption, and simple digital control without feedback or customization, which are important for large switching fabric.

2. Switch Design and Fabrication

Figure 1(a) shows the schematic architecture of the wavelength-selective switch. It consists of 8 sets of 1x8 wavelength demultiplexers, 8 sets of 8x8 broadband switches, and 8 sets of 8x1 wavelength multiplexers. We employed echelle gratings for the wavelength (de)multiplexers. The echelle gratings were designed to split/combine 8 wavelengths from 1480 nm to 1550 nm with 10 nm spacing. Distributed Bragg reflectors (DBRs) are used to increase reflection in echelle gratings, as shown in Fig. 2(a). 8x8 switch arrays were realized with silicon photonic MEMS switches using broadband adiabatic couplers [Figs. 2(b) and (c)], similar to our previous switches [1]. The operating wavelength range of the adiabatic couplers cover entire optical bandwidth in the WDM switches, therefore, identical switch designs were used for all 8x8 switch arrays except for MMI (multimode interference) crossings, which were optimized for the operating wavelength of each array. The 8x8 WDM switch with 8-wavelength...
channels is monolithically integrated on a silicon photonic chip of 9.7 mm x 6.7 mm, as shown in Fig. 1(b). The devices were fabricated on an 8” silicon-on-insulator (SOI) wafer with 220-nm thick device layer in a commercial foundry at TSI Semiconductors. The detailed fabrication process is similar to our previous silicon photonic MEMS switches [1].

Figure 2. (a) Microscope image of the echelle grating. Inset: Close-up SEM image of the DBR mirrors (scale bar: 2 µm). (b) Microscope image of the 8x8 silicon photonic MEMS switch array (Unit cell size: 110 µm x 110 µm). (c) SEM image of the switch unit cell. The bus and coupler waveguides are highlighted with green and red, respectively.

3. Characterization

Figure 3(a) shows the spectral response of a standalone echelle grating, which clearly confirms 8-channel wavelength (de)multiplexing operation from 1480 nm to 1550 nm with 10 nm spacing. The peak insertion loss of 1510 nm wavelength is measured to be 2.1 dB. The silicon photonic MEMS switches turn on at 33V, and turn off at 17V. The switching time is 0.96 µs, similar to our previous switch [1]. Figure 3(b) shows the ON and OFF spectra of the WDM switch with an example path configuration from input port 1 to output port 8 through the 1510 nm wavelength switch block. An extinction ratio as high as 40 dB was observed. Thanks to this high extinction ratio, the estimated crosstalk with fully utilized 8-port input signals is smaller than -30 dB. The on-chip insertion loss distribution of various combinations of input/output ports and wavelengths is plotted in Fig. 3(c). The average insertion loss was estimated to be 13.3 dB, in which two (in and out) echelle gratings causes a loss of ~4.5 dB and the remaining loss of 8.8 dB is from routing waveguides and 8x8 switch blocks. The waveguide routing loss is higher than anticipated due to the fabrication imperfection and can be reduced in future runs.

Figure 3. (a) Spectral response of echelle grating. (b) Representative ON/OFF spectra of the switch device. (c) Insertion loss distribution of the switch device.

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4. References