O-Band Microring Resonator Based Switch-and-Select Silicon Photonic Switch Fabric

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Abstract: This paper for the first time reports an O-band micro-ring resonator-based switch-and-select silicon photonic switch fabric with bent couplers. An average crosstalk ratio of below -40dB is achieved with a 3dB passband of 43.6GHz.

1. Introduction

The exponential growth in the scale and data capacity of data centers is a driving force for high-bandwidth and low-latency network solutions. Photonic switches are widely accepted as a potential key element to meet the growing interconnection performance requirements in data center architectures [1]. Several switching technologies, including micro-electromechanical systems (MEMs) [2], liquid crystal on silicon (LCOS) [3], Mach-Zehnder interferometers (MZIs) [4] and micro-ring resonators (MRRs) [5], have demonstrated space or wavelength selective switching functionalities. Given the requirement in data centers for high bandwidth density at low cost and power consumption, it is not surprising that silicon photonics, fabricated in high-volume CMOS compatible foundries, is a prime candidate. MRR based switch-and-select silicon photonic switches have been studied and demonstrated with the modalities of both space and wavelength switching in the C-band [6]. Previous research demonstrates the easing of critical coupling condition achievement by using bent waveguides [7]. In this paper, we report the first integrated O-band MRR based switch-and-select switch fabric with bent couplers. Static characterization is experimentally performed to evaluate the performance of the switch, demonstrating its excellent crosstalk suppression ratio performance of up to over 40dB with a 3dB passband of 43.6GHz.

2. Device Design and Packaging

A schematic of the design of the 4×4 MRR-based switching circuit is depicted in Fig. 1(a), where 32 add-drop ring resonators are deployed with micro-heaters for on/off-state tuning. The MRR add-drop filters are assembled in eight 1×4 bus structures acting as spatial (de)multiplexers. Each MRR unit has two waveguides with a bent angle $\theta = 30^{\circ}$ to couple the light in and out of the ring. The bent coupling structure is employed in order to enhance the coupling efficiency that facilitates the O-band operation. The two parallel waveguides are designed to be with different widths (410nm for rings and 342nm for bent waveguides) according to the phase matching condition [8]. The gap d between the bent waveguides and the ring resonators is kept constant at 154nm. The radius r of the ring is set to 14.6μm.

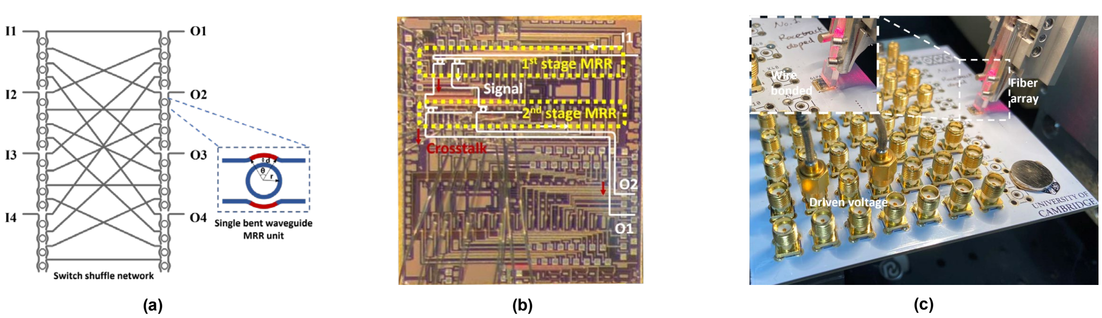

Fig 1(a) Schematic of 4×4 MRR based switch-and-select switch with bent couplers. (b) Microscope photo of the fabricated device. (c) Testbed of the silicon chip bonded onto a PCB and coupled using a fiber array.

The silicon switch chip, Fig 2(b), was fabricated in a multi-project-wafer (MPW) run through a commercial 200mm silicon-on-insulator (SOI) platform by Advanced Micro Foundry. The silicon die is bonded onto a customized PCB for electrical fan-out, as shown in Fig 1(c). Aluminum wires are bonded to connect the chip and PCB bond pads while a 20-channel SMF fiber array with 127 μm fiber pitch is used to couple the light into/out of the chip at a 7° angle.

3. Device Static Characterization

In the switch crosstalk characterization, an O-band tunable laser set to 1311.7nm with -0.5dBm input power is used. The operation of the optical switching circuit is characterized in terms of the power transfer functions for each path, as shown in Fig 2(a). Data on six paths of the total 16 paths is shown due to electrical open circuits. On-chip losses as low as 4.5dB are measured along with an average -41.75dB and -28.3dB worst-case crosstalk ratio. Detailed measurement of a representative path 1-2 is shown by Fig. 2(b) indicating the -46.7dB overall path crosstalk ratio. The measurement in on-off extinction of the two individual ring resonators in path 1-2 is shown by Fig. 2(c), showing -26.6dB and -20.1dB, respectively.

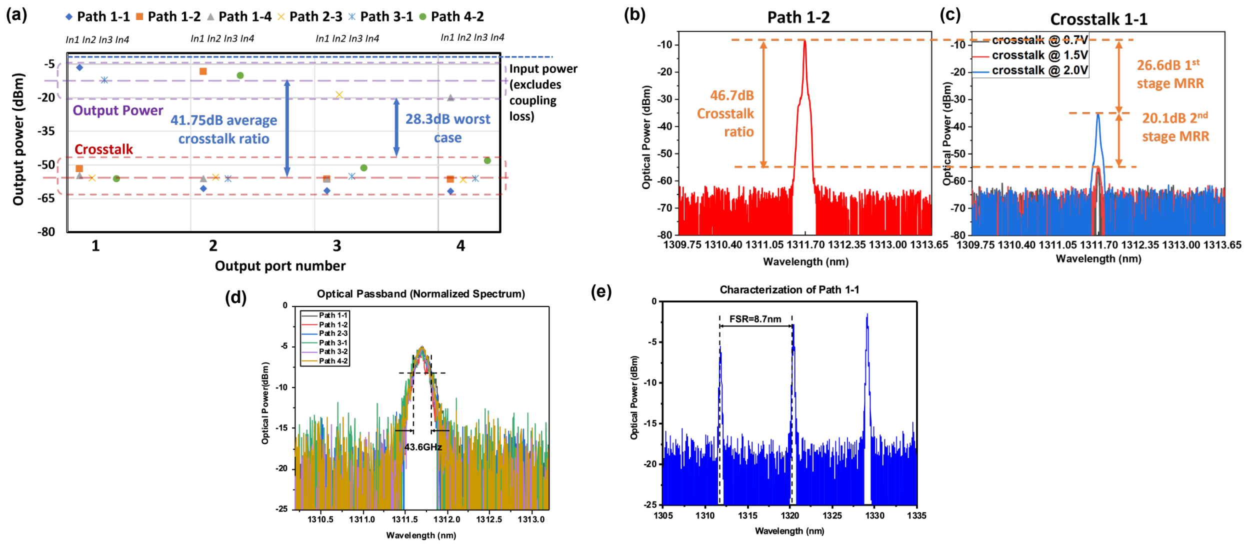

Fig 2(a) Measured optical power map of the switch, the purple and red rectangle outlines the outpower power level and crosstalk leakage, respectively. (b) Overall crosstalk ratio measurement for path 1-2. (c) Crosstalk leakage at output 1. (d) Normalized spectra of a set of representative paths, resolution is set at 0.02nm. (e) Free-spectral range of the MRR switch.

A semiconductor optical amplifier (SOA)-based broadband source is used to verify the device free spectral range (FSR) and passband. The spectra are measured and recorded using an optical spectrum analyzer with a resolution of 0.02nm. The normalized spectra of a set of representative paths are shown in Fig. 2(d), indicating a 3dB passband of 43.6GHz. The normalized transmission spectrum of the representative path 1-1, containing several resonant peaks is shown in Fig. 2(e), indicates an FSR of 8.7nm.

4. Conclusion

In this paper, we present the first O-band silicon MRR-based switch-and-select optical switch fabric. The switch device exhibits on average below -40dB crosstalk ratio, benefiting from the topological first-order crosstalk suppression. Additionally, a 43.6GHz 3dB passband is achieved, demonstrating great potential for high-performance switching applications in data centers.

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5. Reference

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