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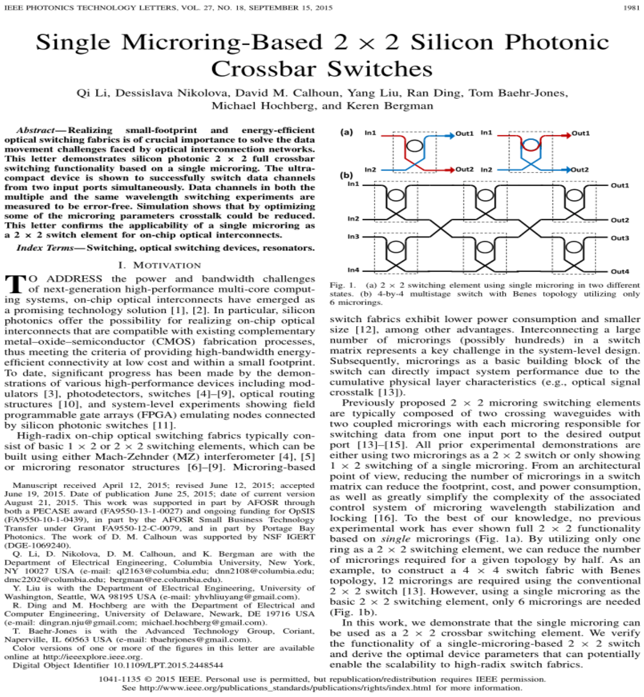
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Single Microring-Based 2 × 2 Silicon Photonic Crossbar Switches

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***Abstract*—Realizing small-footprint and energy-efficient optical switching fabrics is of crucial importance to solve the data movement challenges faced by optical interconnection networks. This letter demonstrates silicon photonic 2 × 2 full crossbar switching functionality based on a single microring. The ultra-compact device is shown to successfully switch data channels from two input ports simultaneously. Data channels in both the multiple and the same wavelength switching experiments are measured to be error-free. Simulation shows that by optimizing some of the microring parameters crosstalk could be reduced. This letter confirms the applicability of a single microring as a 2 × 2 switch element for on-chip optical interconnects.**

***Index Terms*—Switching, optical switching devices, resonators.**

I. Motivation

TO ADDRESS the power and bandwidth challenges of next-generation high-performance multi-core computing systems, on-chip optical interconnects have emerged as a promising technology solution [1], [2]. In particular, silicon photonics offer the possibility for realizing on-chip optical interconnects that are compatible with existing complementary metal–oxide–semiconductor (CMOS) fabrication processes, thus meeting the criteria of providing high-bandwidth energy-efficient connectivity at low cost and within a small footprint. To date, significant progress has been made by the demonstrations of various high-performance devices including modulators [3], photodetectors, switches [4]–[9], optical routing structures [10], and system-level experiments showing field programmable gate arrays (FPGA) emulating nodes connected by silicon photonic switches [11].

High-radix on-chip optical switching fabrics typically consist of basic 1 × 2 or 2 × 2 switching elements, which can be built using either Mach-Zehnder (MZ) interferometer [4], [5] or microring resonator structures [6]–[9]. Microring-based switch fabrics exhibit lower power consumption and smaller size [12], among other advantages. Interconnecting a large number of microrings (possibly hundreds) in a switch matrix represents a key challenge in the system-level design. Subsequently, microrings as a basic building block of the switch can directly impact system performance due to the cumulative physical layer characteristics (e.g., optical signal crosstalk [13]).

Fig. 1. (a) 2 × 2 switching element using single microring in two different states. (b) 4-by-4 multistage switch with Benes topology utilizing only 6 microrings.

Previously proposed 2 × 2 microring switching elements are typically composed of two crossing waveguides with two coupled microrings with each microring responsible for switching data from one input port to the desired output port [13]–[15]. All prior experimental demonstrations are either using two microrings as a 2 × 2 switch or only showing 1 × 2 switching of a single microring. From an architectural point of view, reducing the number of microrings in a switch matrix can reduce the footprint, cost, and power consumption, as well as greatly simplify the complexity of the associated control system of microring wavelength stabilization and locking [16]. To the best of our knowledge, no previous experimental work has ever shown full 2 × 2 functionality based on *single* microrings (Fig. 1a). By utilizing only one ring as a 2 × 2 switching element, we can reduce the number of microrings required for a given topology by half. As an example, to construct a 4 × 4 switch fabric with Benes topology, 12 microrings are required using the conventional 2 × 2 switch [13]. However, using a single microring as the basic 2 × 2 switching element, only 6 microrings are needed (Fig. 1b).

In this work, we demonstrate that the single microring can be used as a 2 × 2 crossbar switching element. We verify the functionality of a single-microring-based 2 × 2 switch and derive the optimal device parameters that can potentially enable the scalability to high-radix switch fabrics.

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