# 8x8 λ-router in Silicon-on-insulator Technology for Optical Networks on Chip

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*Abstract*— **In this paper, we demonstrate a compact 8x8 λ-router using multimode- interference (MMI) crossing based on the microring resonator. The 8x8 λ-router was designed and fabricated with a CMOS compatible silicon on insulator technology. The experimental results are in good agreement with the modeling. The basic add drop filters of the devices exhibit losses of -2 dB and on/off contrast of the resonance of 20 dB. The total losses for one channel are about -4 dB and the imbalance between the 8 channels is lower than 2 dB.**

***Keyword Si photonics, ring resonator, add-drop filter, λ-router***

## I. INTRODUCTION

To satisfy the interconnect requirements of chip multiprocessors in the future, Optical network on chip (ONoC) have recently become popular as one solution for increasing bandwidth, decreasing latency and reducing power [1-3]. ONoC provides an optical link between a certain number of input ports and output ports by routing signals based on their wavelengths,and is composed of three types of blocks: (1) transmitters, (2) passive integrated photonic routing structure (λ-router) and (3) receivers [4]. The λ-router is a passive wavelength-routed optical network constituting the core of the ONoC, which is composed of add-drop filters.

## II. ROUTER ARCHITECTURE

A 8x8 optical network on chip is shown in Fig.1, each square in Fig.1 represents an add-drop filter.

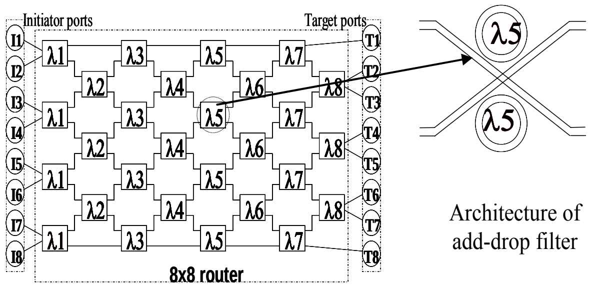


Fig.1 Schematic view of a 8x8 ONoC.

The add-drop filter is λ-router basic building block. It works in a similar way to a classical electronic switch from a functional view [4], where the non-resonant signal propagates in diagonal direction and the resonant is dropped in straight direction as shown in Fig.2.

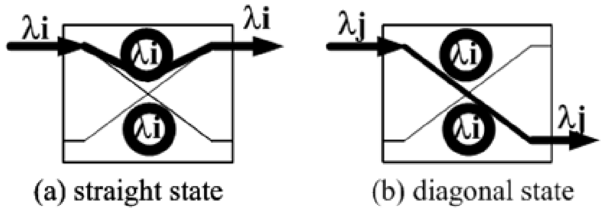


Fig.2 Functional states of add-drop filter.

The optical path of the signal in the 8x8 network depends on the signal wavelength. For example, if the initiator port I4 wants to communicate to the target port T4, then, I4 must send signal with wavelength λ8 through the λ-router.

## III. ADD DROP FILTER

The microring resonator is formed by tightly bent Silicon-On-Insulator (SOI) waveguides. Compared with racetrack resonators, microring resonators have a wider free spectral range (FSR), a smaller size and a better quality factor [6-7].

The modeling of the add-drop filter is performed with full vectorial finite difference mode solvers to calculate the variation of the effective index and the losses versus the wavelength of the modes that propagate in the straight and bend waveguides. The coupled modes theory (CMT) is used to calculate the spectral response of the device. The final design of the add-drop filter is validated with a 3D FDTD calculation.

In the basic building blocks of the λ-router, 2 by 2 MMIs are used to reduce the cross talk and the crossing losses of the device. 2.5 μm radius microrings with a radius difference of 10 nm allow a free spectral range of 24 nm and a spacing between channels of 3 nm.

As the radius of the μring is very low, the width of the input and output straight waveguide of each add-drop filter is reduced to 0.38 μm in order to increase the coupling factor with the ring resonator.

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## IV. FABRICATION AND CHARACTERIZATION

Based on the analysis of the previous section, we design and fabricate the 8x8 λ-router on 200nm CMOS line as shown in Fig.3. The radius difference of every close microring is 10nm.

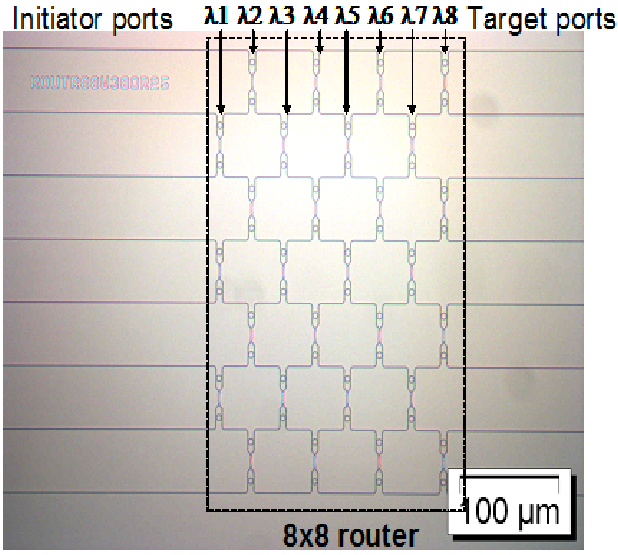


Fig.3 8x8 λ-router

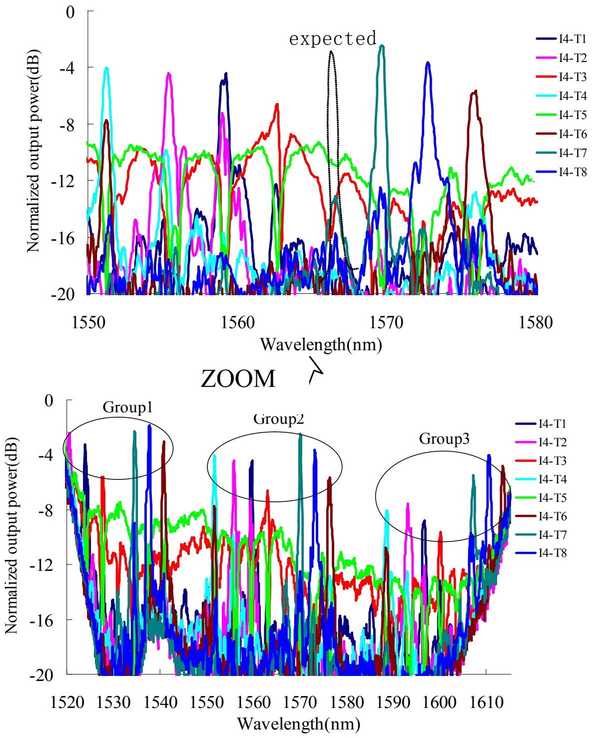


Fig.4 Measured transmission spectrum of the optical 8x8 λ-router at T1-T8 with light injected at port I4

The measured transmission spectrum of the optical 8x8 λ-router with light injected at port I4 is shown in Fig.4b. Three groups are observed presenting a good repeatability. The close up picture of the first group (Fig4a) reveals seven peaks which are equally space along the spectral range. The path I4-T5 is throughput path for the input I4: no resonance is observed. So the eighth peak misses. The red peak from I4-T3 is a little bad because the coupling from the throughput path disturbs the resonant spectra of path I4-T3,and the resonance from I4-T3 is close to the expected peak of throughput path I4-T5.

In Fig.4, the total loss of the studied channels is about -4 dB and the imbalance between the 8 channels is lower than 2 dB. The output efficiency for every path is a little weak (about 10dB to 20dB), because each path has to travel 6-8 waveguide crossings. The crosstalk between some drop channel is a little larger(about -4dB). This can be overcome by using the discrete source.

Similar measurements were performed for all input ports of the 8x8 network. There is about ≤1nm difference for the same resonance with different input port because of the fabrication imperfection.

In conclusion, we present optical 8x8 λ-router using MMI crossing based the microring resonator. To our knowledge, this is the first experimental demonstration of such passive circuits.


## ACKNOWLEDGMENT

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