MEMS based wavelength selective optical switching for integrated photonic circuits

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Abstract: MEMS-enabled wavelength selective switching by controlling resonance in high-index-contrast optical ring resonators is demonstrated. Fabrication and design considerations for the MEMS switches are explored. Experimental optical switching results are reported.

OCIS codes: (130.3120) Integrated optics devices; (230.3990) Microstructure devices; (230.2090) Electro-optical devices; (060.1810) Couplers, switches, and multiplexers

1. Introduction

We report on a device that performs wavelength selective switching for integrated photonic circuits. High-index-contrast (HIC) optical ring resonators provide wavelength selectivity [1-3] with a microelectromechanical system (MEMS) parallel plate structure providing switching. The HIC materials system allows small radii (~10μm) ring resonators with low propagation loss and large free-spectral-range.

The resonance of the ring resonator is enabled or disabled by a lossy material membrane that is moved into and out of the ring resonator's evanescent field [2,3] (see Fig. 1). When the lossy material is up, the resonant wavelength couples to the drop port. When the lossy material is down, the resonant wavelength passes by the ring resonator unaffected. The MEMS device controls the lossy material's position.

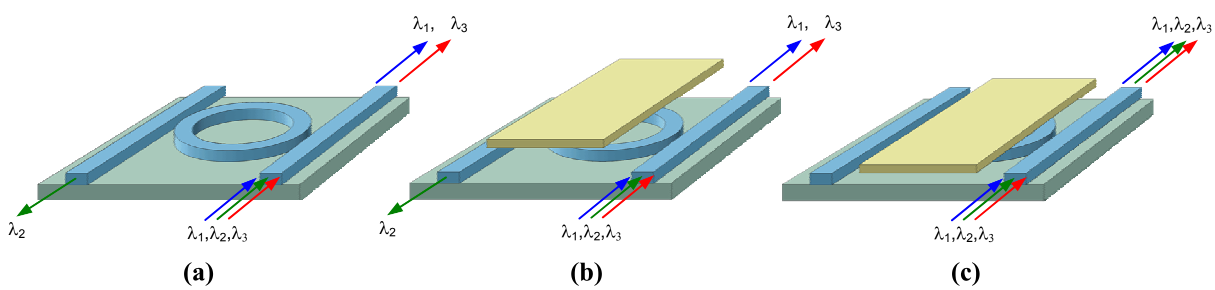
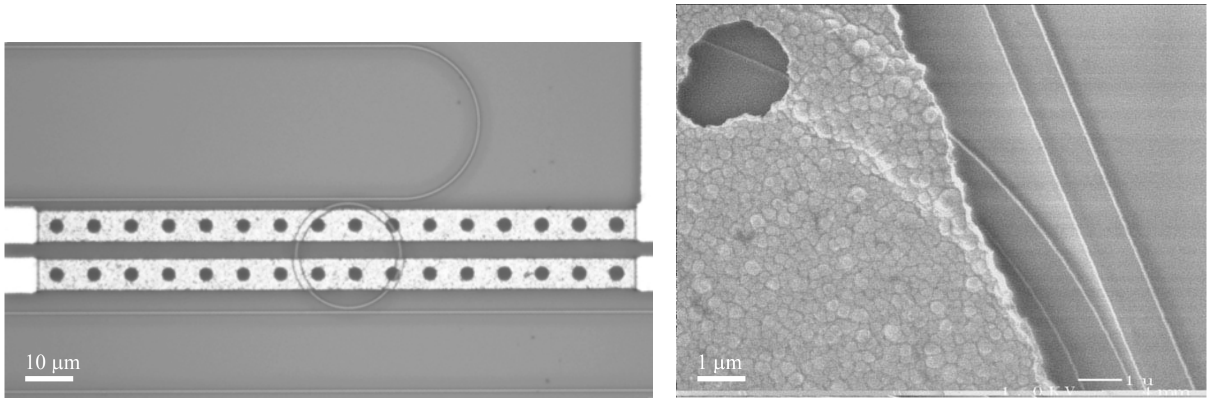


Fig. 1. **(a)** A passive ring resonator filter illustrating its wavelength dropping behavior. **(b)** and **(c)** Ring resonator switch with the lossy material shown in and out of the evanescent field of the ring resonator, illustrating the switching behavior.

2. Design and fabrication

The ring resonator design parameters include the waveguide core and cladding materials, cross-sectional waveguide shape, ring resonator radii, and coupling distances. The waveguide fabrication process begins by growing a 3μm layer of silicon oxide on a silicon substrate. A layer of silicon rich silicon nitride is then deposited and subsequently patterned and etched using e-beam lithography and reactive-ion etching (RIE).

The MEMS design takes advantage of the "pull-in" effect of parallel plate actuators [4]. The two stable equilibrium regimes of the actuator create a mechanical binary switch. The fabrication process for the MEMS device uses standard CMOS fabrication techniques. The bridge structure (the lossy material and top parallel plate actuator) is aluminum. The sacrificial material is polysilicon that is etched with xenon difluoride (XeF_2). Images of the device are shown in Fig. 2.

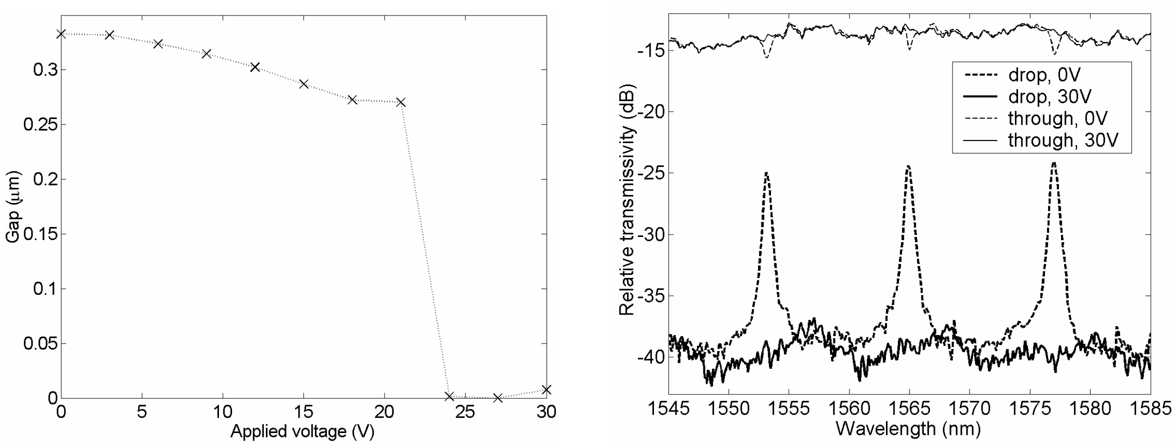


(a) (b)

Fig. 2. **(a)** Optical image of a MEMS ring resonator switch. **(b)** SEM of the bridge over the ring resonator.

3. Experimental results

Electro-mechanical testing of the MEMS actuator indicates the pull-in voltage is 24V (see Fig. 3a). Fig. 3b shows the optical switching results. Although the switching contrast is fairly good, there is excessive loss seen when the MEMS bridge is un-actuated. The loss comes from residual stress induced deformations in the aluminum that causes the initial gap between the aluminum and the ring resonator to be half of what the optical design required. Work is on-going to reduce this deformation.



(a) (b)

Fig. 3. **(a)** Displacement versus applied voltage. **(b)** Spectral response of the optical switch in its two states.

4. References

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