Design and Simulate Electro-Optic (EO) Polymer Logic Device

Ramin F. Firoozi, Zeyu Pan, Harish Subbaraman, Dr. Ray T. Chen, Advisor

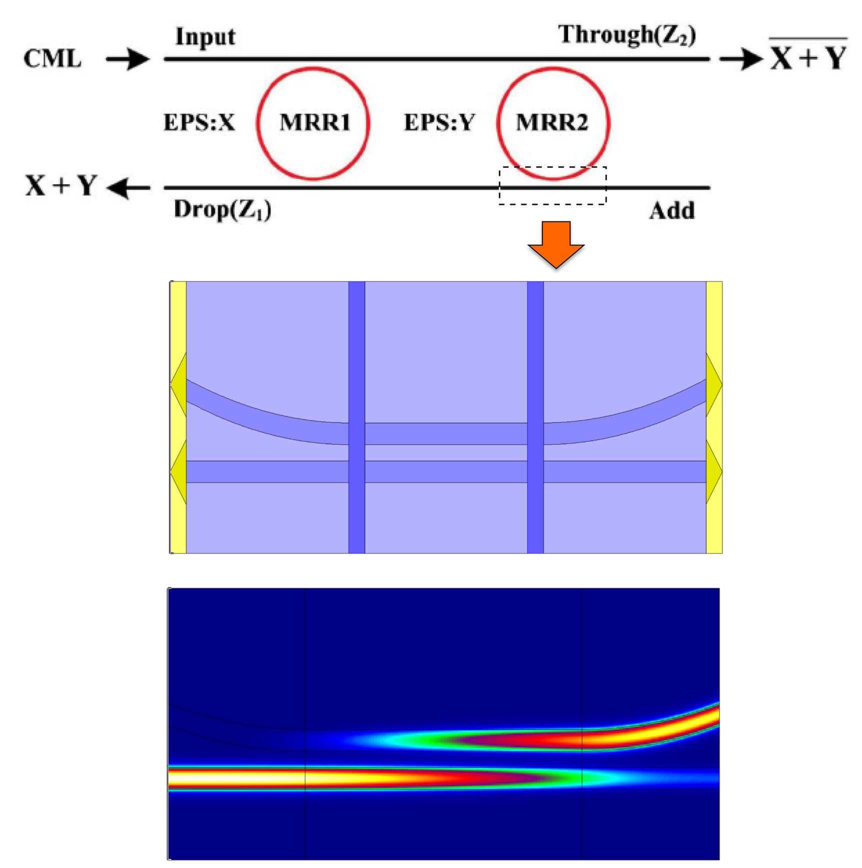
Cockrell School of Engineering, The University of Texas at Austin, Austin, Texas 78701

Abstract

The primary objective here is to design and simulate electro-optic (EO) polymer OR/NOR logic gate based on bus waveguides and microring resonators, each of which implements a switching operation.[1] Simulation results show that the OR/NOR directed logic gate could be achieved.

Introduction

- Direct logic structures utilize microring resonators (MRR) and bus waveguides as switching elements to control the propagation direction of light going through them.
- Each MRR is driven by an electrical pulse signal, which is regarded as the operand. The high and low levels of the electrical pulse signal represent logic 1 and 0, respectively, while the larger and smaller optical output powers at the output ports represent logic 1 and 0, respectively.



X	Y	Z1 (Drop)	Z2 (Through)	Resonance state of MRR1	Resonance state of MRR2
0	0	0	1	Off	Off
1	0	1	0	On	Off
0	1	1	0	Off	On
1	1	1	0	On	On

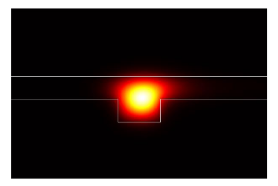
Table1. Truth Table for Device and Resonance State of MRRs

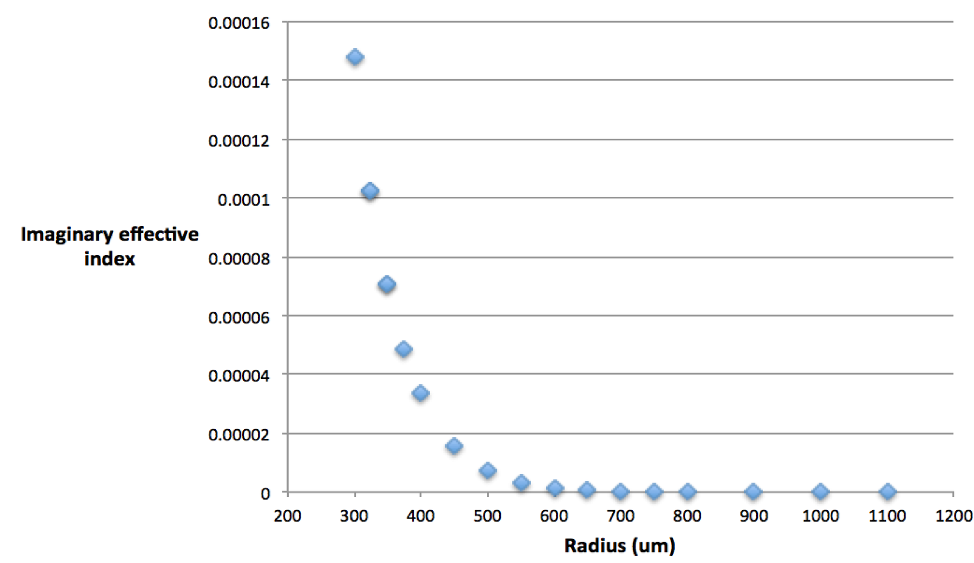
Simulation and Design

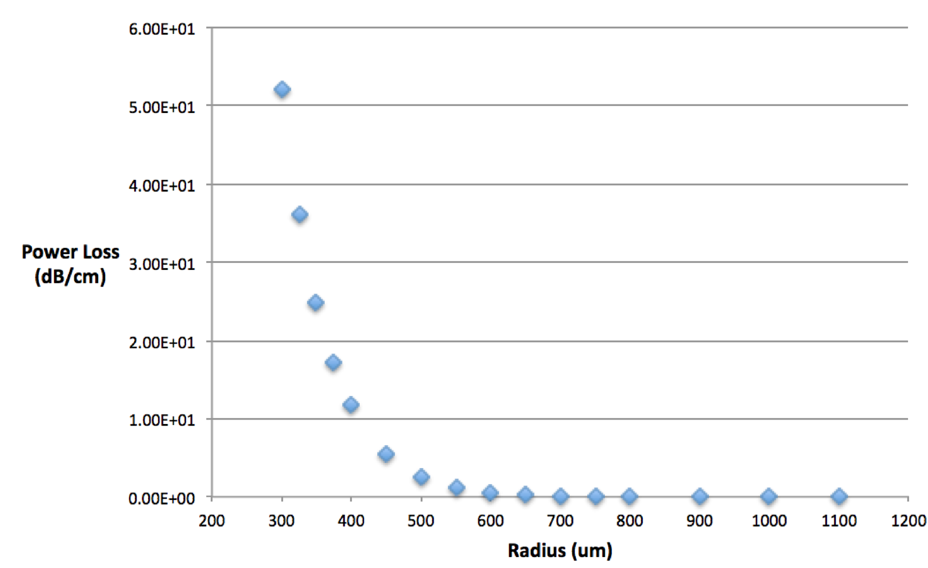
In this section, we present the method that was used to find the optimal radius for the design of microring resonators.

- To calculate bend losses, a transparent boundary condition on the outer edge of the bend were carried out using Film Mode Matching (FMM) solver of FIMMWAVE.
- The results have been verified using Lumerical MODE Solutions.

$$\text{Loss (dB/cm)} = 20 \log_{10} e \,.\, n_i \,.\, k_0$$







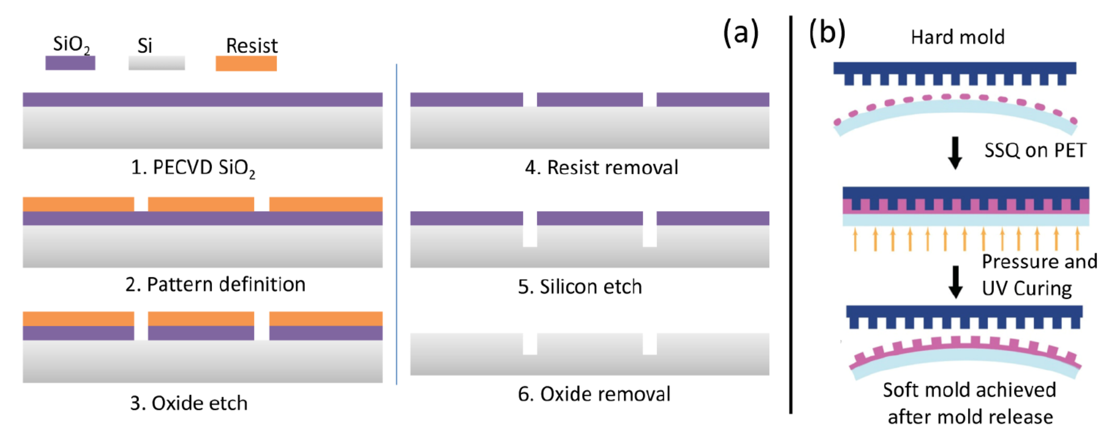
EO effect

The electro-optic effect is based on a change in the refractive index of the material when it is subjected to an electric field. [2]

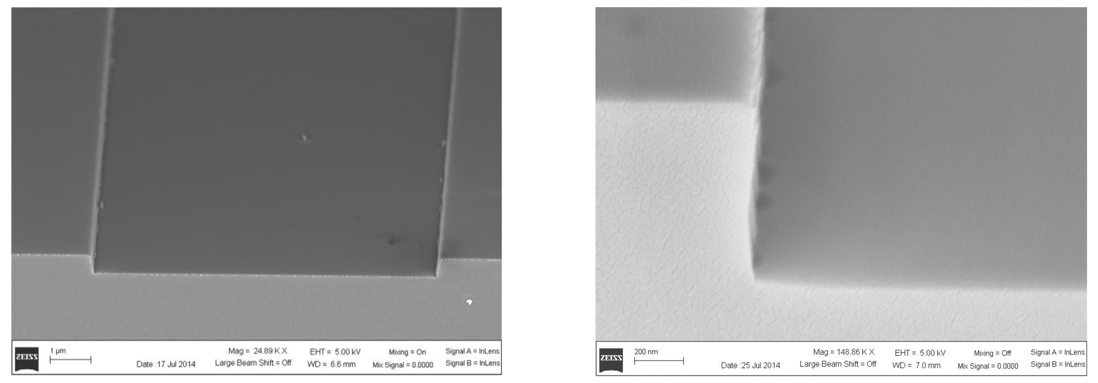
$$\Delta n_i = -\frac{1}{2} n_i^3 r_{ik} E_k$$

Fabrication Process

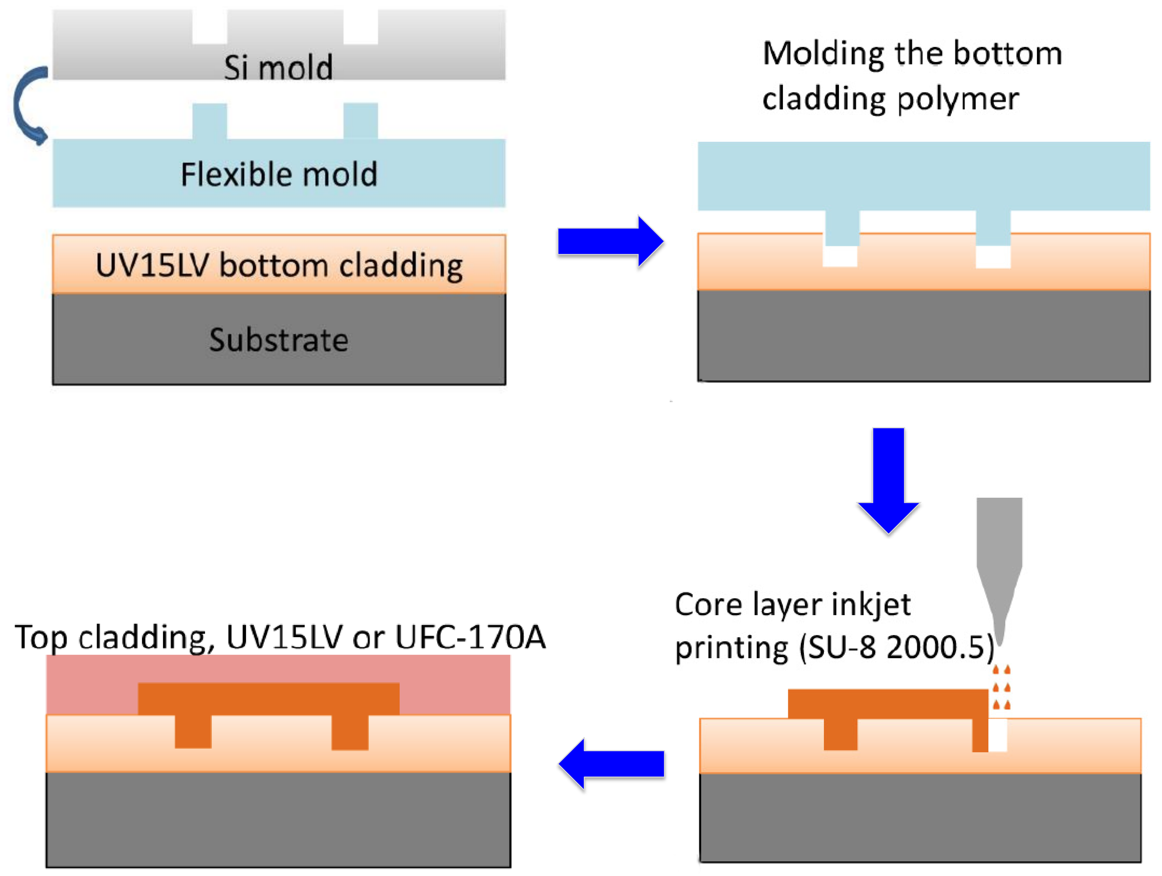
Mold Fabrication



(a) silicon master mold fabrication process (b) soft mold replication from master mold



- Waveguide pattern is formed on the Bottom Cladding using imprinting Technique
- Waveguide core layer is ink-jet printed (SU-8 2000.5)



Summary and conclusions

- All of the switches operate simultaneously, thus resulting in high speed logic operation.
- The fabrication processes involved are fully roll-to roll compatible, which can enable high throughput, low cost and volume manufacturing of photonic devices.
- Critical coupling is achieved by setting the transmission coefficient equal to loss factor.

Radius (um)	Length (um)	Gap (um)	Loss Factor	Transmission	Coupling Coefficient
750	116	1.5	0.54969009	0.54978505	0.6977364
850	112.4	1.5	0.52328709	0.52265907	0.7268275
950	112.9	1.5	0.48929051	0.48927559	0.7606094

Literature cited

[1] P. Zhou, L. Zhang, Y. Tian, and L. Yang, "10 GHz electro-optical OR/NOR directed logic device based on silicon micro-ring resonators," Opt. Express **39**(7) 1937-1940 (2014)

[2] R. Ridder, A. Driessen, E. Rikkers, P. Lambeck, and M Diemeer, "Design and fabrication of electro-optic polymer modulators and switches," Optical Materials **12** 205-214 (1999)

[3] Jianyi Yang, Qingjun Zhou, Feng Zhao, Xiaoqing Jiang, Brie Howley, Minghua Wang, Ray T. Chen, "Characteristics of optical bandpass filters employing series-cascaded double-ring resonators" Optics Communications 228 (2003) 91-98

Acknowledgments

I would like to thank the Equal Opportunity in Engineering Program and NSF-LSAMP for providing the funding.

For further information

Please contact Ramin F. Firoozi at *ramin.fallahfiroozi@mavs.com*.