An Investigation of MEMS-based Photonic Switch Structure

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Large-scale photonic switches have shown immense promise for developing high-speed computing over the past decade. An efficient mechanism for speeding up communications, improving performance and enhancing security is to create an optical infrastructure with fast response time, low power consumption, and low optical loss. A Microelectromechanical system (MEMS) based photonic switch with a vertically actuated adiabatic coupler has been demonstrated to achieve optical coupling between different on-chip optical waveguides with an optical loss of ~3.7 dB [1]. The switching performances relies on the suspended optical waveguide ends tapering and terminating into sharp tips of ~100 nm width to achieve low-loss transmission, which requires advanced and expensive fabrication steps [1]. The objective of this research is to investigate a novel energy-efficient and high-performance MEMS-based mechanical switching structure with a suspended waveguide.

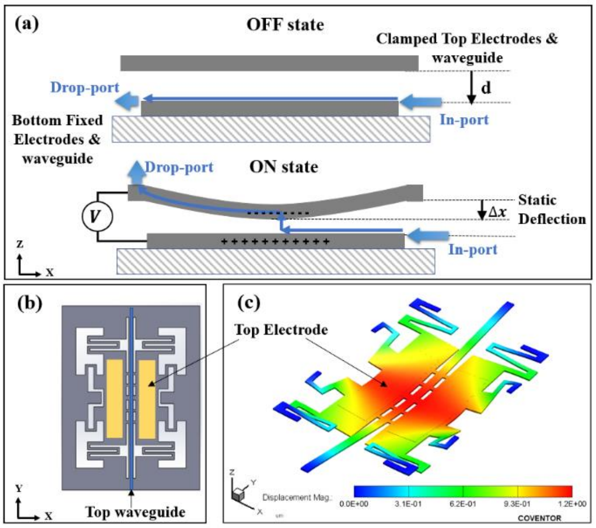

Figure 1. MEMS photonic switch design: (a) cross-sections of the structure in ON and OFF states; (b) membrane design; and (c) finite element simulation result

Figure 1(a) depicts the switch in the OFF and ON states. In the OFF state, the top waveguide, which is placed on the thin silicon nitride (SiNx) membrane, is suspended above the bottom fixed bus waveguide at a distance *d* (approximately 2 μm). Optical light injected from the in-port can travel through the bottom waveguide to the other end without interruption. In the ON state, MEMS electrostatic gap-closing actuators (two pairs of parallel plate electrodes) are applied to pull the top membrane and waveguide downward to the bottom waveguide and allow the light to couple to the top waveguide efficiently from the in-port. Light then propagates to the drop-port. The detailed membrane structure is illustrated in Figure 1(b). This designed structure has a size of 180 μm × 250 μm, and a deflection displacement Δx of 1.2 μm when the input voltage is 13 VDC. However, the simulation shows this membrane has a low resonance frequency (~40 kHz) which has a great effect on the switching time. Further work is required to improve the optical switching speed, which should provide fast responses for applications ranging from long-haul communication networks to on-chip interconnects.

[1] T. J. Seok, N. Quack, S. Han, R. S. Muller and M. C. Wu, *Large-scale broadband digital silicon photonic switches with vertical adiabatic couplers* (Optica, vol.3, no. 1, 2016) p 64.