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Targeting femto-joule on-chip optical switches using a silicon-organic hybrid ring resonator

Abstract

In order to improve the performance of integrated photonic devices, silicon waveguides hybridized with organic materials has become an increasingly important research area. Central to the entire discipline of silicon-organic hybrid (SOH) photonics is the concept of slot waveguides covered by an organic cladding. In this work, we investigate on the power consumption of a SOH ring resonator based on a slot waveguide phase shifter. As unique feature, this ring resonator consists of a slot waveguide, which is partially introduced in a racetrack ring configuartion.¹ This partially slotted ring resonator has been demonstrated to obtain large resonance wavelength shifts.² In the present work, we show that this ring concept allows a low energy consumption by reducing the capacitance length and using advanced nonlinear optical polymers. We predicted a drastically reduced energy consumption of 0.07 fj/bit at a driver voltage of 1 V. The current findings add substantially to the understanding of SOH slot waveguide based phase shifter and ring resonators for lowpower applications.

Ringresonator Design

The partially slotted ring resonator concept combines an efficient slotwaveguide phase shifter with a low loss and strongly guiding silicon stripwaveguide in a single ring.





Fabricated with SiGe BiCMOS pilotline on 200 mm wafer at



Institute of innovative microelectronics, Frankfurt(Oder), Germany



Device Fabrication





Energy Consumption

The **Energy per bit** for On-Off-Keying is given by [1]:

$$W_{bit} = \frac{1}{4} \cdot C_{slot} \cdot U^2 = \frac{1}{4} \cdot \frac{\varepsilon_0 \cdot n_{eop}^2 \cdot h}{s} \cdot L_{slot} \cdot U^2$$

partially slotted ring resonator ($L_{slot} = 18 \mu m$) \rightarrow Energy consumption scales with 18 г

Conclusion

Partially slotted ring resonator is fabricated using a SiGe BiCMOS



- size. \rightarrow Sub-Femtojoule energy consumption.
- \rightarrow CMOS compatible driver voltages.
- \rightarrow For comparison: silicon based modulators have typically 15 times higher energy consumption [2].

pilotline

- PMMA/DR1 was deposited as cladding material
- power consumption by using silicon-organic hybrid slot-Low waveguide phase shifter

References:

[1] G. Li et al., IEEE Journal of Selected Topics in Quantum Electronics, vol. 19, pp. 95–113, 2013. [2] L. Chen et al., Optics Express, vol. 17, pp. 15248–15256, 2009.



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- Further information about the partially slotted ring resonator concept can be found in: • P. Steglich et al., "Novel ring resonator combining strong field confinement with high optical quality factor," IEEE Photonics Technology Letters, vol. 27, no. 20, pp. 2197–2200, 2015.
- P. Steglich et al., "Partially slotted silicon ring resonator covered with electro-optical polymer", Proc. SPIE 9891, 98910R, 2016.