Trimming and tuning of Silicon-On-Insulator Ring Resonators

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Silicon-on-insulator is an ideal material platform for the fabrication of integrated optical components due to the high index contrast, the compatibility with CMOS processes and the transparency for telecom wavelengths. A major drawback of silicon is the low electro-optic coefficient which inhibits the realization of modulators or switches. Liquid crystal can be used as a cladding layer and this enables to tune and modulate optical components in silicon because the effective index of the modes is dependent on the orientation of the liquid crystal in the cladding layer. Limited tunability of ring resonators in silicon up to 1 nm for TE based waveguides was achieved [1] for ring resonators with a bend radius of 6 µm. Recently we have demonstrated much larger tunability of 4.5 nm in TE waveguides and 31 nm in TM based waveguide [2], which means that it is possible to tune over almost the whole telecom C-band which spans from 1530 to 1565 nm.

Deep UV lithography using 193 nm sources is used to fabricate the silicon photonic chips. It has to be noted, however, that the precision requirements for CMOS are much less stringent than they are for photonics. A variation of 10% in the critical dimensions is acceptable for CMOS but dramatic for many photonic devices. Ring resonators are extremely vulnerable to fabrication errors. As a result, the resonance of the fabricated ring resonators often differs considerably from the designed value, which is unacceptable for many applications. To overcome the fabrication imperfections, the ring resonators have to be trimmed or tuned to the desired resonance wavelength. Tuning requires a constant voltage signal over the LC layer. Trimming on the other hand means that the component is set to its desired resonance wavelength by an irreversible process.

In this work we have deposited a mixture of polymerizable liquid crystal on top of the ring resonators. The ring resonators were then tuned by applying a voltage signal over the liquid crystal overlay. The tuning range that we obtained was 0.75 nm. Then the orientation of the liquid crystal was frozen for a certain voltage applied by illumination with UV light. The polymerization process induces a small redshift of the resonance wavelength, but the final resonance wavelength remains constant, even after removing the voltage. We have applied this trimming process for different voltages and we have measured a trimming range of 0.56 nm. The trimming was demonstrated in a configuration with limited tuning range, but this method will hold also for ring resonators with large tuning range.

References

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