An integrated tunable reflector

Ang Li[1,2,*], Yufei Xing[1,2], Wim Bogaerts[1,2]
[1]Photonics Research Group, Ghent University-IMEC, 9052 Ghent, Belgium
[2]Center for Nano and Biophotonics, Ghent University, 9052 Ghent, Belgium
[*] ang.li@ugent.be

With past decade's development, silicon photonics grows to be one of the most promising platforms for integrated optics. Despite its rich component library that includes grating couplers, multi-mode interferometers (MMI), Mach-Zender-Interferometers (MZI), ring resonators, modulators, germanium photodetectors and doped heaters etc., some key basic building blocks are still missing or not very well developed and standardized. An integrated tunable reflector is one of them. Suggested by its name, such a device should provide a widely tunable reflectivity controlled by common tuning mechanism, like thermo-optic and free carrier plasma effects. Besides, it should fully fit into existing silicon photonics platforms, meaning no CMOS incompatible materials involved. In terms of its reflection spectrum, preferably it can switch between flat and wavelength dependent spectrum depending on the specific application.

Popular approaches for such devices are either Bragg grating based or ring resonator based [1,2]. The former one has poor tunability while ring resonator based devices are usually narrow band in its spectrum. Here, we propose a loop-ended MZI based reflector, as in Fig. 1(a). This structure can easily be incorporated in circuits shown in Fig. 1(b-c).

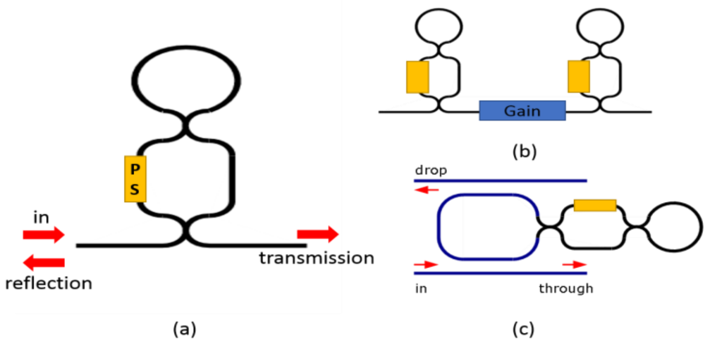

Fig. 1 (a) gives the schematic of our reflector with a phase shifter. (b) and (c) present two potential applications of such reflectors.

We use the optical circuit simulator *Caphe* by Luceda Photonics to perform rich simulations for such a device. The main design freedoms include the two arm lengths of the MZI and the coupling coefficients of the two directional couplers (DCs). A balanced MZI ($\Delta L = 0$) will generate a flat reflection spectrum as shown in Fig. 2(a), while a length difference $\Delta L \neq 0$ will result in a periodic wavelength dependence as in Fig. 2(b). For the latter case, a special spectrum where only one wavelength has zero reflection (shown in Fig. 2(c)) can be obtained if $m\lambda = 2\Delta L n_{eff}$, where m is the interference order, similar to that of a MZI. λ is the wavelength that has zero reflection, and n_{eff} is the effective index. This special reflection spectrum can have valuable applications in optical sensors and novel filters [3]. The simulated tunability is shown in Fig. 2(d). The blue and red curves in Fig. 2 (a,b,d) correspond to a circuit with ideal (DCs) and with dispersive (DCs), respectively.

Besides the length difference of the MZI, the performance of the reflector depends strongly on the coupling coefficients of its two directional couplers as evident in Fig. 3.

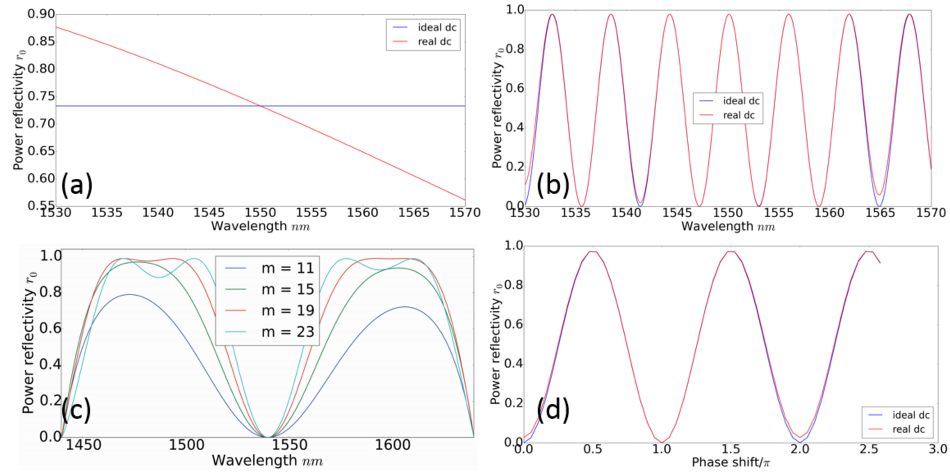

Fig. 2 (a) presents a flat reflection spectrum. (b) shows a wavelength dependent spectrum. (c) is a special case where only one point in a wide wavelength range suffers 0 reflection. (d) gives the simulated tunability.

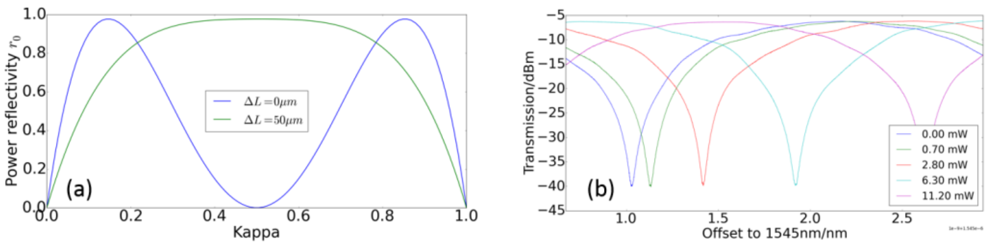

Fig. 3 (a) shows the influence of coupling coefficients on the reflectivity at 1550nm, (b) presents our active measurement. Less than 6.3mW can generate a 35dB change in transmission/reflection

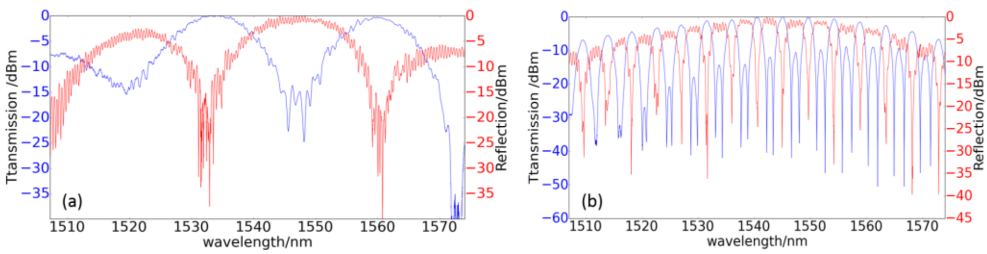

Fig. 4 (a) is a measured flat reflection spectrum. (b) is wavelength dependent.

In Fig. 4 we present our measurement results. Fig. 4(a) demonstrates a relatively flat reflection spectrum while (b) gives a strongly wavelength dependent spectrum. The index matching fluid with an index equals 1.54 was used in order to minimize the reflection at the fiber/air interface. The dynamic tuning by thermo-optic heater is given in Fig. 3(b). Less than 6mW can generate a 35 dB change in transmission/reflection.

References

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