Concentrically curved silicon waveguide WDM couplers

H. Renner*, M. Krause and E. Brinkmeyer

Technische Universität Hamburg-Harburg, Hamburg, Germany, *Email: renner@tu-harburg.de

Abstract

We present designs for wavelength-selective directional couplers where two dissimilar silicon waveguides are concentrically curved to tailor non-periodic spectral transmission bands for WDM applications and pump-signal separation. The design is based on calculating the supermodes including the curvature leakage losses.

Wavelength selectivity is one of the most interesting features of photonic circuits with applications such different as signal routing in WDM systems or pump-Stokes separation in cascaded Raman lasers and amplifiers. Besides periodic refractive-index modulation (as in waveguide Bragg gratings or photonic crystals) with sharp output spectra but also increased scattering losses due to the abrupt index variations, directional couplers comprising two dissimilar waveguides are also well-known to be wavelength-selective. They are able to couple only a limited wavelength band around the crossover wavelength of the fundamental-mode dispersion curves of the two waveguides while passing all other wavelengths. To make the dispersion curves cross each other and synchronize both modes, the two waveguides need to have a small-dimension core of a higher refractive index and a large-dimension core with a lower refractive index. Unfortunately, when focussing on silicon photonics with all waveguides consisting of silicon the core indices are all the same.

To overcome this limitation of the silicon platform we present designs for wavelength-selective directional couplers where two dissimilar silicon waveguides are concentrically curved (see Fig. 1) to achieve phase synchronicity and full overcoupling of the two individual waveguide modes around a desired wavelength only. Although such a concept was proposed as early as in 1980 [1], its potential has scarcely been exploited in practice up to now.

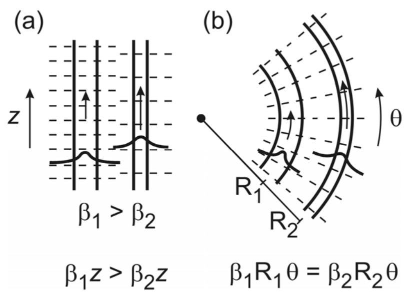

Fig. 1: Asynchronous modes in a straight coupler (a) can be made synchronous in a curved coupler (b).

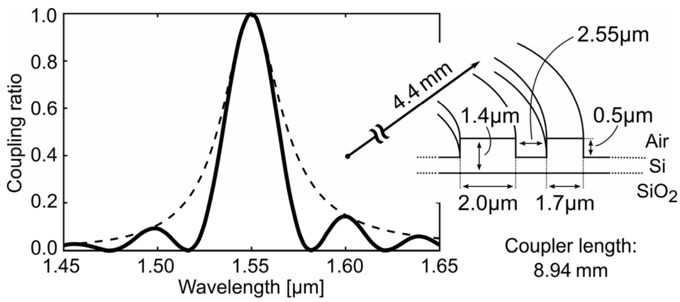

Fig. 2: Transmission spectrum of a curved silicon waveguide WDM coupler (see data in the inset).

Calculating the leaky supermodes [2] we have designed WDM couplers based on curved silicon rib waveguides and photonic wires with low curvature losses. Fig. 2 shows a design optimized for transmission around 1550nm with all other transmission bands suppressed, facilitating, e.g., pump and Stokes separation even in cascaded Raman components [3].

We have shown that even for silicon photonics with its restriction to making all waveguides of silicon, directional WDM couplers can be designed if concentrically curved waveguides are used.

[1] Y. Murakami, "Coupling between curved dielectric waveguides," *Appl. Opt.,* vol. 19, pp. 398-403, 1980.

[2] M. Krause, "Finite-Difference Mode Solver for Curved Waveguides with Angled and Curved Dielectric Interfaces," *J. Lightwave Technol.,* accepted for publication.

[3] M. Krause, H. Renner and E. Brinkmeyer, "Raman lasers in silicon photonic wires: unidirectional ring lasing versus Fabry-Perot lasing," *Electron. Lett.,* vol. 45, pp. 42-43, 2009.