

Molding silicon waveguide devices with sub-wavelength structures

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Silicon-on-insulator is emerging as mayor platform for the realization of photonic integrated circuits. Due to its high index contrast ($\Delta n \approx 2$) it allows for very compact designs, which can be incorporated into CMOS fabrication processes, thereby paving the way for optical interconnects. However, as in most fabrication platforms, the refractive indices of the materials (silicon and silicon dioxide) can scarcely be modified, limiting the design space for waveguide devices. This has changed radically with the introduction of sub-wavelength gratings (SWGs), which enable refractive index engineering in silicon devices [1]. SWGs are periodic structures, alternating layers of silicon and a low refractive index material (silicon dioxide, air, or polymer), with a pitch small enough to suppress diffraction. An SWG behaves as a homogenous medium with an equivalent refractive index, which depends essentially on the duty cycle of the structure. A large variety of devices have been realized using this approach, including fiber-to-chip couplers and wavelength de-multiplexers. Here we present a multimode interference coupler with a sub-wavelength slot in its center [Fig. 1(a)]. The slot synthesizes a strip of low equivalent refractive index in the center of the device, thereby changing the modal interference in such a way that the length of the device is reduced by half without affecting its performance [2]. Furthermore, we discuss the use of SWG structures for engineering not only an equivalent refractive index but also dispersion. This enables the design of devices with enhanced bandwidth, such as directional coupler shown in Fig. 1(b). The transversal SWG structure compensates the variation of beat length with wavelength, extending the bandwidth of the device by a factor of five [3]. Interestingly this concept can be extended to multimode interference couplers, yielding operational bandwidths of around 450nm [4].

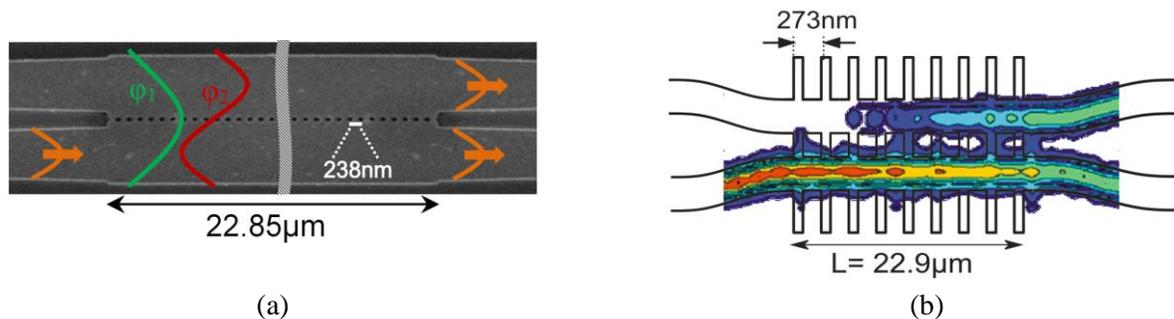


Figure 1. a) A 2x2 MMI coupler with an index engineered sub-wavelength slot that reduces by half the length of the device. **b)** A directional coupler with a dispersion engineered sub-wavelength structure that increases the bandwidth of the device by a factor of five.

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