ORIGINAL PARA SER INCLUIDO EN EL REPOSITORIO RIUMA

Re-inventing Multimode Interference Couplers Using Subwavelength Gratings

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Multimode-Interference (MMI) devices (see Fig. 1a) are fundamental building blocks in photonic integrated circuits, where they are used for power splitting and combining, optical switches and modulators, Mach-Zehnder interferometers and 90º hybrids for coherent optical receivers [1]. MMIs are based on the self-image principle, by which the guided modes of the multimode region interfere to form replicas of the input field with specific amplitude and phase relations. These relations are known to depend on i) the core/cladding refractive indexes (n_1/n_2), ii) the core width (W) and length (L) of the multimode region and iii) the number, width and position of the access ports. In this work, we show that by using sub-wavelength structures within an MMI, the self-imaging properties can be significantly altered, leading to ultra-short or ultra-broadband devices.

Subwavelength gratings (SWGs) are structures with a pitch below the Bragg condition, so that they behave as an effective medium [2]. This means that in Silicon-on-Insulator (SOI) technology, equivalent refractive indexes between those of the core (Si) and the cladding (e.g. SiO_2 or SU-8) can be obtained tuning the SWG pitch and duty cycle. This "refractive-index-engineering" has already been successfully applied to a variety of integrated devices [3,4]. The dispersion properties of SWGs have only very recently been explored [5].

Here we use the concept of refractive index engineering to propose and experimentally demonstrate a reduced size, slotted 2x2 MMI coupler. The key point of this device is the design of a longitudinal SWG slot placed at the center of the multimode region (Fig. 1b). When properly designed, this slot changes the propagation constants of the even modes without affecting the odd modes. As a result the length of the device is halved without degrading its performance: Fig. 1(c) shows that, in a back-to-back configuration, the shortened device even exhibits a slightly better measured extinction ratio than the conventional device. We also present an ultra-broadband 2x2 MMI SWG coupler (Fig. 1d) which is based on SWG dispersion engineering. The tapered SWG structures at the input and output provide low-loss and low-reflection transitions between conventional silicon-wire waveguides and the SWG multimode region. The SWG multimode region is designed to achieve a nearly wavelength independent self-imaging length. The device exhibits a bandwidth of 450nm (1260nm–1675nm), which is five times higher than conventional MMIs. In this range, the insertion loss, power imbalance and MMI phase error, as simulated with 3D FDTD, are below 1dB, 0.6dB and 3º, respectively.

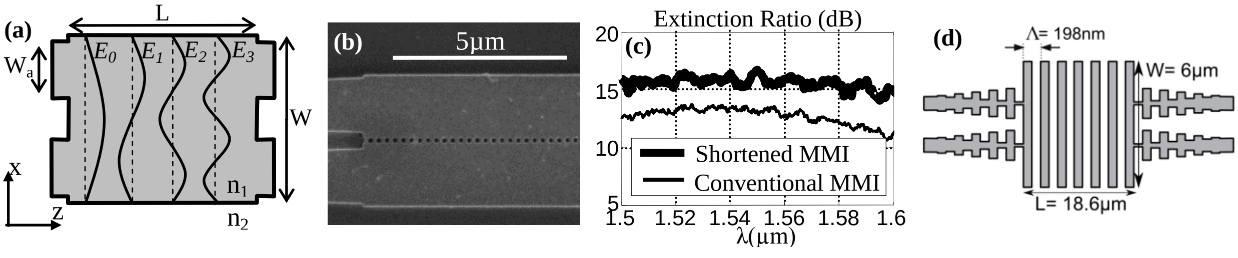

Fig. 1 **(a)** Geometry of a conventional 2x2 MMI coupler. E_0, E_1, E_2 and E_3 are the field profiles of the four lowest order modes. **(b)** Scanning Electron Microscope Image of the reduced size slotted 2x2 MMI coupler. **(c)** Measured extinction ratio of fabricated back-to-back MMI test structures. Device footprints are: Shortened 3.5µm x 23µm and Conventional 3.5µm x 47µm. **(d)** Geometry of the ultra-wideband 2×2 MMI coupler with SWG multimode region.

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