Molding the flow of light through subwavelength devices

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***Abstract*— Patterning of subwavelength scale structures onto dielectrics allows engineering the local refractive index, dispersion and anisotropy of materials, thus opening new design possibilities which give unprecedented control of light shape in photonic integrated circuits. In this talk we will present an overview of our recent advances in subwavelength based devices of practical importance including fiber-chip couplers, ultra-broadband MMI devices, mode and polarization multiplexers and bragg deflectors.**

Keywords— silicon photonics; metamaterials; subwavelength gratings; integrated optics; nanophotonics

I. Introduction

Subwavelength gratings (SWGs) are periodic structures with a pitch (Λ) smaller than the wavelength of light propagating through it [1]. In this condition diffraction is frustrated and the structure behaves like a quasi-homogeneus medium with optical properties (refractive index, dispersion, birefringence) that can be tuned in a limited range. This redounds in a greater flexibility for device design and can be exploited to develop high performance integrated silicon photonic devices [2,3].

First SWG based devices exploited the capability of engineering the refractive index, for example, to get high efficiency fiber to chip grating couplers with a single etch step [4] or low loss waveguide crosses [5]. Further research into SWGs capabilities allowed us to also engineer the dispersion of waveguide modes which makes us possible to design ultra high bandwidth MMI couplers exceeding 300 nm bandwidth [6]. These devices are of fundamental importance in telecommunication transceivers, sensing etc.

Advances in the field during the last years has led us to understand the important limitations caused by leakage losses [7] and random fabrication jitter [8], and more recently we are working towards a better modeling of the anisotropy of SWG materials [9] which will allow us to engineer the metamaterial birefringence and get novel advances devices [10].

In this invited talk we will review some of the advances made by our group in the field, with special emphasis in new SWG devices for polarization and mode multiplexing. Also recent results of a bragg grating deflector, capable of coupling the wire waveguide mode to an arbitrary optical beam that can propagate freely in the horizontal plane of the chip (while being trapped vertically in a slab) will be presented.

II. References

[1] I. Staude and J. Schilling, Nat. Photonics, 11, 274–284, 2017
[2] R. Halir, et al., Laser Photonics Rev., 9, 25, 2015
[3] P. Cheben, et al., Opt. Express, 23, 22554–22563, 2015
[4] R. Halir, et al., Optics letters 34.9 (2009): 1408-1410.
[5] P.J.. Bock, et al, Opt. Express 18, 16146-16155 (2010)
[6] R. Halir, et al., Laser Photonics Rev., 10, 1039, 2016
[7] J. D. Sarmiento-Merenguel, et al., Opt. Lett., 41, 3443-3446, 2016
[8] A. Ortega-Moñux, et al., Opt. Express, 25, 12222-12236, 2017
[9] J.M. Luque-González,, et al., Optics letters 43.19 (2018): 4691-4694.
[10] R. Halir, et al., 2018 20th International Conference on Transparent Optical Networks (ICTON). IEEE, 2018.

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