Subwavelength metamaterial structures for silicon photonics

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***Abstract*— Sub-wavelength periodic metamaterial structures are enabling the design of silicon photonic devices with unprecedented performance in the near infrared band. However, for applications in the promising mid-infrared band it is expected that they acquire even more prominence because for longer wavelengths it is far easier to fabricate structures with a sub-wavelength pitch. Here we report our recent progress in the electromagnetic modeling of sub-wavelength structures, and we will review some of our latest advances in the development of sub-wavelength based devices operating both at near and mid-infrared wavelengths.**

Keywords—sub-wavelength grating waveguides; near infrared; mid infrared; silicon photonics.

Sub-wavelength grating (SWG) structures are periodic arrangements of materials with a pitch small enough to suppress diffraction. Conveniently designed they behave as meta-materials whose properties (index of refraction, dispersion and anisotropy) are completely determined by their geometry and the operating wavelength. They have become an essential design tool in the field of integrated photonics, enabling breakthrough devices, which clearly overcome the limitations imposed by their conventional counterparts [1]. Highly efficient surface grating couplers, fiber-chip edge couplers, compact and ultra-broadband multimode interference couplers, wavelength multiplexers or polarization splitter and rotators are only some examples of devices enabled by sub-wavelength structures. Photonics biosensing is another area where SWG technology is receiving great attention due to the enhanced sensitivity achieved by engineering the waveguide mode confinement [2-4].

Most of the aforementioned sub-wavelength engineered devices have been developed for the near-infrared telecom band in the well-established silicon-on-insulator (SOI) platform. The emerging field of Mid-IR photonics provides further design opportunities for SWG structures, because the longer operating wavelength results in larger sub-wavelength feature sizes, relaxing fabrication requirements. This opens up new prospects for SWG based devices, such as suspended waveguides than can potentially operate in the full silicon transparency window [5].

In this talk we will review some of our recent advances in the SWG technology, covering both fundamental issues, such as design rules to control leakage classes and our recent progress on devices in the near and mid infrared bands.

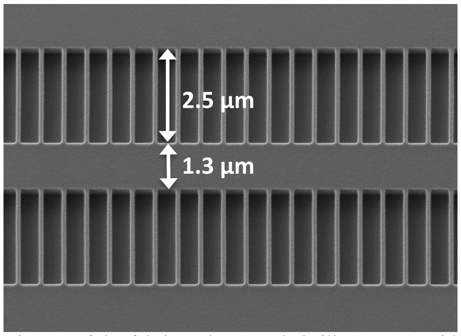

Fig. 1: SEM image of the fabricated suspended silicon waveguide with lateral sub-wavelength grating cladding to operate at a wavelength of 3.8 µm.

This work was supported by the Ministerio de Economía y Competitividad, Programa Estatal de Investigación, Desarrollo e Innovación Orientada a los Retos de la Sociedad (cofinanciado FEDER), Proyecto TEC2013-46917-C2-1-R, Proyecto TEC2016-80718-R and the Universidad de Málaga.

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