Silicon Photonic Bragg Grating Structures for Spectral Filtering

Alejandro Ortega Moñux[1,*], Alejandro Fernández Hinestrosa[1], Carlos Pérez Armenta[1], José Manuel Luque González[1], Alejandro Sánchez Postigo[1,4], Daniel Pereira Martín[1], J. Gonzalo Wangüemert-Pérez[1], Robert Halir[1], Abdelfettah Hadij-Elhouati[1], Pavel Cheben[2], Jens H. Schmid[2], M. Milanizadeh[2], Shurui Wang[2], Kevan K. Mackay[3], Winnie N. Ye[3], Íñigo Molina-Fernández[1]

[1] *Telecommunication Research Institute (TELMA), Universidad de Málaga, CEI Andalucía TECH, Louis Pasteur 35, 29010 Málaga, Spain*
[2] *National Research Council Canada, 1200 Montreal Road, Bldg. M50, Ottawa K1A 0R6, Canada*
[3] *Department of Electronics, Carleton University,Ottawa,ONK1S5B6,Canada*
[4] *Department for Quantum Technology, University of Münster, Heisenbergstraße 11, 48149 Münster, Germany*
Keywords: Silicon photonics, Silicon-on-Insulator, Silicon Nitride, Integrated Bragg gratings, Mach-Zehnder Interferometer, Contradirectional couplers, Spectral filters

Integrated optical filters play a key role in modern optical systems, finding extensive applications in quantum optics, biosensing, programmable photonics, and telecommunications. Among the most commonly used structures utilized for implementing integrated optical filters are ring resonators and Bragg gratings. Bragg gratings are characterized by a periodically perturbed refractive index profile along the propagation direction. By precisely engineering the strength of the perturbation along the grating length, filters with arbitrary spectral responses can be achieved. In this work we summarize our recent contributions to integrated Bragg filters in Si-photonics, covering designs for applications ranging from telecommunications to quantum optics. Our approach is based on the cladding-modulated Bragg grating configuration proposed in [1], which provides precise control of the grating coupling coefficient over a wide dynamic range with relaxed minimum feature sizes. To recover the reflected drop signal without the need for external circulators, we explore two alternatives, based respectively on a Mach-Zehnder-Interferometer scheme [2] and the concept of contra-directional coupling. Finally, we demonstrate a dynamically tunable and reconfigurable multi-wavelength notch filter which makes use of a periodic heater element to control the self-coupling coefficient [3].

We acknowledge funding from the Ministerio de Economía y Competitividad, PID2019-106747RB-I00, PRE2020-096438, PID2020-115204RB-I00, TED2021-130400B-I00, Ministerio de Ciencia, Innovación y Universidades, FPU19/02408, FPU21/04914, Junta de Andalucía P18-RT-1453, P18-RT-793, UMA-FEDERJA-158, National Research Council Canada (CSTIP, HTSN210, STR2-0102); and Universidad de Málaga.

[1] Pereira-Martín, D., et al. "Complex spectral filters in silicon waveguides based on cladding-modulated Bragg gratings." *Optics Express* 29.11 (2021): 15867-15881.

[2] Fernández-Hinestrosa, A., et al. "O-band add-drop filters with complex cladding modulated Bragg gratings in Mach-Zehnder configuration." Submitted to *Optics Letters*. Under revision.

[3] Pérez-Armenta, C., et al. "Thermally induced sideband generation in silicon-on-insulator cladding modulated Bragg notch filters." *Optics Express* 31.13 (2023): 22225-22232.