

Title: Cavity Resonator Integrated Grating Filters: a mesoscale platform for nonlinear optical devices

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Abstract (300mots)

Cavity Resonator Integrated Grating Filters (CRIGFs) are mesoscopic resonant grating based heterostructures that allow excitation of a confined mode through a grating coupler etched on top of a waveguide. The excited mode is spatially bound by two Distributed Bragg Reflectors (DBR) which confine modes in a Fabry-Perot resonator. They can give rise to high Q-factor resonances that will superimpose on the non-resonant transmission and reflection curves of the structure.

In recent years, such devices have been demonstrated at multiple wavelengths, ranging from the near infrared around 850 nm wavelength to the mid infrared around 4.65 μm wavelength through the telecom range near 1.55 μm . They have been used as filters or wavelength selective output coupler to stabilize laser diodes in the NIR or MIR spectral ranges. Recent reported work using nonlinear lithium-niobate thin films as waveguides also show the demonstration of second-harmonic generation in these structures under continuous wave (CW) excitation.

We will discuss the physics underlying the CRIGF performances, and present recent theoretical and experimental results on their non-linear optical operation.

Technical Review (500 mots)

Cavity Resonator Integrated Grating Filters (CRIGFs) [1] are mesoscopic grating waveguide coupler heterostructures made of two grating-based DBRs surrounding a Grating Coupler, all of which being defined on top of a planar waveguide. As such, they constitute planar waveguide Fabry-Perot cavities with surface-normal input/output coupling. Their optical spectral response under excitation by a focused beam exhibit sharp Fano resonances. The latter resonances result from the coupling of the input beam to strongly confined modes inside the grating heterostructure. The spatial confinement of the mode gives rise to “mode in the box” [2] behavior resulting in several interesting properties such as the existence of high order modes [3], or an exceptional angular tolerance [4] that allows their use as wavelength selective reflectors for laser diode stabilization in external cavities [5,6].

More recently, we have demonstrated enhanced and tunable second harmonic generation under CW optical excitation using CRIGF on Lithium Niobate thin films [7-8]. In that context, the mesoscale size of the CRIGF allows for several interesting features. First, the large mode size used for the excitation allows the use of large input powers as compared to usual nanophotonics cavities. Increasing the excitation power has experimentally revealed strong thermal effects and large bistability in the linear and non-linear spectra, phenomena we will present in detail at the conference. Furthermore, the mesoscopic scale of the confinement heterostructure allows the spatial and spectral features of the selected excitation mode inside the cavity to be tailored to optimize its Q-factor. For SHG operation, we will show that a careful design of the central grating permits the excitation of a low-loss high-Q-

factor dark-mode of the coupling grating, which, in turn, is theoretically predicted to enable the enhancement of the SHG efficiency by a factor of more than 10^3 . Alternatively, using long cavities supporting multiple confined modes, these mesoscale devices can also be adjusted to promote multi-resonant non-linear components for optical operations going beyond the singly-resonant SHG configuration studied so far to include doubly-resonant SHG or multi-resonant sum-frequency mixing.

In brief, we will discuss the CRIGF physical properties and present our recent results on the optimization of CRIGFs for non-linear applications.

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