



HAL
open science

Using Cavity Resonator Integrated Grating Filters for second harmonic generation

François Renaud, Stéphane Calvez, Antoine Monmayrant, Evgeni Popov, Anne-Laure Fehrembach, Olivier Gauthier-Lafaye

► **To cite this version:**

François Renaud, Stéphane Calvez, Antoine Monmayrant, Evgeni Popov, Anne-Laure Fehrembach, et al.. Using Cavity Resonator Integrated Grating Filters for second harmonic generation. 22nd International Conference on Transparent Optical Networks (ICTON), Jul 2020, Bari, Italy. hal-03008892

HAL Id: hal-03008892

<https://laas.hal.science/hal-03008892v1>

Submitted on 17 Nov 2020

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Using Cavity Resonator Integrated Grating Filters for second harmonic generation

François Renaud ^(1,2), Stéphane Calvez ⁽¹⁾, Antoine Monmayrant ⁽¹⁾, Evgeni Popov ^(2,3), Anne-Laure Fehrembach ⁽²⁾ and Olivier Gauthier-Lafaye ⁽¹⁾

1 - LAAS-CNRS, Univ. de Toulouse, CNRS, F-31400 Toulouse, France

2 - Aix Marseille Univ, CNRS, Centrale Marseille, Institut Fresnel, F-13013 Marseille, France

3 - Institut Universitaire de France, France

Tel: (33) 5 61 33 78 80, e-mail: olivier.gauthier-lafaye@laas.fr

ABSTRACT

Cavity Resonator Integrated Grating Filters are micro-structured integrated resonators that exhibit resonances with Q factors in order of a thousand and that can be excited with focussed beams. These two characteristics make them particularly attractive as base components for non-linear optical generation. In this contribution, we experimentally demonstrate second harmonic generation in such devices under continuous wave excitation and show that the measured performance are in good agreement with theoretical predictions.

Keywords: non-linear optics, micro-resonator, subwavelength gratings.

1. INTRODUCTION

Cavity Resonant Integrated Grating Filters (CRIGF) were introduced by Prof. Ura's team in 2012[1] and have thus been thoroughly investigated by different teams. They allow narrow-band and efficient spectral filtering under tightly focused excitation [2], and can achieve polarization independence [3], and can be finely tuned by variational design [4], [5]. They have been demonstrated in different wavelength ranges from the near-infrared [2] to the mid-infrared [6]. It has now been shown that their intrinsic properties stem from the excitation of a localized mode of high Q factor localized under the main grating coupler [7] (see fig.1).

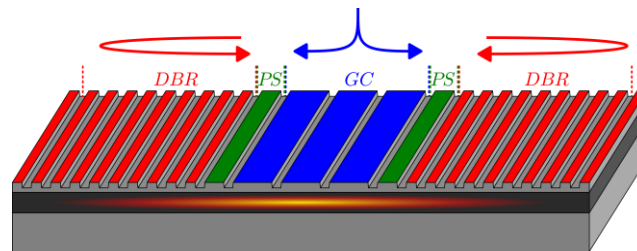


Figure 1. schematic of a CRIGF highlighting its different parts : grating coupler (GC, blue), phase sections (PS, green) and distributed Bragg reflectors (DBR, red).

This localized mode with a high Q factor can be interesting for non-linear optical operations such as second harmonic generation (SHG) as it provides strong optical field enhancement within a small volume. We have recently demonstrated such SHG in these devices when made on a thin film of Lithium Niobate, a well-known material for its non-linear optical properties [8]. In this paper, we will detail recent experimental results obtained on such devices.

2. RESULTS

Samples are fabricated on a NanoLN-provided wafer made of a LiNbO₃ substrate, a 2.3- μm -thick SiO₂ spacer and a thin, 300-nm-thick LiNbO₃ film oriented along its Z-cut direction. The grating layer was made of a 70-nm-thick Si₃N₄ layer deposited using low-temperature ICP-PECVD deposition. Electron-beam lithography was used to define the grating structures in a 130-nm-thick PMMA resist. After development, RIE dry etching was performed using a CHF₃/O₂ chemistry. It should be noted that the LiNbO₃ layer acts as a stop etch during this fabrication step, resulting in smooth, homogeneous etching base. As a last step, a 460-nm-thick SiO₂ capping layer was deposited using once again ICP-PECVD. This capping layer results in a low-reflectivity stack around the target pump wavelength of 1.55 μm . For this wavelength of operation and the stack described above, the GC period is around 865 nm, with a DBR period half that of the GC.

The fabricated CRIGF exhibited sharp resonance peaks around 1.55 μm , and the SHG generation was found to follow exactly the resonances, as shown on figure 2.

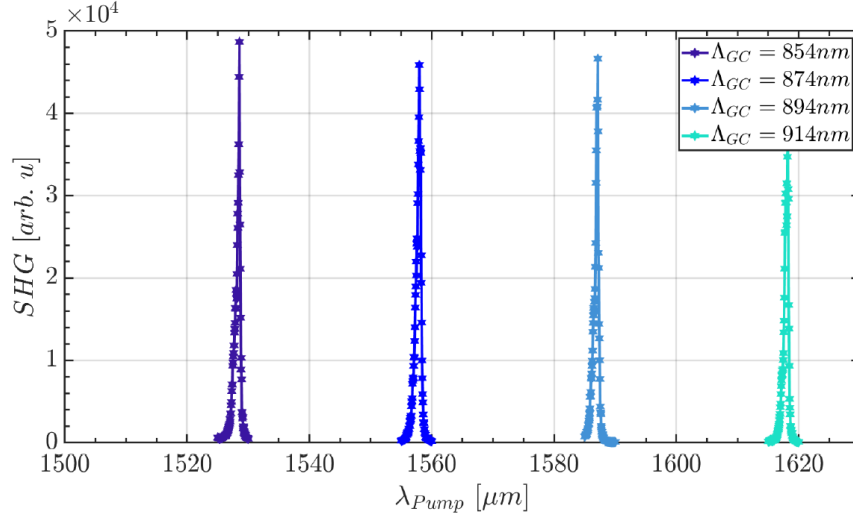


Figure 2. Evolution of the SHG intensity with the pump wavelength for 4 different CRIGF periods indicated in the inset.

We will present results achieved on these filters and compare them to theoretical results. Routes towards higher SHG efficiency will also be presented.

ACKNOWLEDGEMENTS

Authors gratefully acknowledge support from the ANR under grant ANR-ASTRID-RESON. The authors also thankfully acknowledge the LAAS cleanroom team for technical support and technological expertise provided within the French RENATECH network of cleanroom facilities. F. Renaud acknowledges PhD grant from DGA under supervision from P. Adam.

REFERENCES

- [1] K. Kintaka, T. Majima, J. Inoue, K. Hatanaka, J. Nishii, et S. Ura, « Cavity-resonator-integrated guided-mode resonance filter for aperture miniaturization », *Opt. Express*, vol. 20, n° 2, p. 1444–1449, 2012.
- [2] X. Buet, E. Daran, D. Belharet, F. Lozes-Dupuy, A. Monmayrant, et O. Gauthier-Lafaye, « High angular tolerance and reflectivity with narrow bandwidth cavity-resonator-integrated guided-mode resonance filter », *Opt. Express*, vol. 20, n° 8, p. 9322–9327, 2012.
- [3] K. Kintaka, T. Majima, K. Hatanaka, J. Inoue, et S. Ura, « Polarization-independent guided-mode resonance filter with cross-integrated waveguide resonators », *Opt. Lett.*, vol. 37, n° 15, p. 3264–3266, 2012.
- [4] S. Augé, A. Monmayrant, S. Pelloquin, J.-B. Doucet, et O. Gauthier-Lafaye, « Tunable graded cavity resonator integrated grating filters », *Opt. Express*, vol. 25, n° 11, p. pp.12415-12420, mai 2017, doi: 10.1364/OE.25.012415.
- [5] K. Kintaka, K. Asai, K. Yamada, J. Inoue, et S. Ura, « Grating-Position-Shifted Cavity-Resonator-Integrated Guided-Mode Resonance Filter », *IEEE Photonics Technol. Lett.*, vol. 29, n° 2, p. 201-204, janv. 2017, doi: 10.1109/LPT.2016.2636229.
- [6] O. Gauthier-Lafaye *et al.*, « Mid-infrared ($\sim 4.65\mu m$) cavity resonator integrated grating filters », in *Conference on Lasers and Electro-Optics Europe (CLEO/Europe) & European Quantum Electronics Conference (EQEC) 2017*, Munich, Germany, juin 2017, doi: 10.1109/CLEOE-EQEC.2017.8087087.
- [7] N. Rassem, A.-L. Fehrembach, et E. Popov, « Waveguide mode in the box with an extraordinary flat dispersion curve », *J. Opt. Soc. Am. A*, vol. 32, n° 3, p. 420, mars 2015, doi: 10.1364/JOSAA.32.000420.
- [8] F. Renaud, A. Monmayrant, S. Calvez, O. Gauthier-Lafaye, A.-L. Fehrembach, et E. Popov, « Second-harmonic-generation enhancement in cavity resonator integrated grating filters », *Opt. Lett.*, vol. 44, n° 21, p. 5198, nov. 2019, doi: 10.1364/OL.44.005198.