M2 internship subject

Title: Second harmonic generation in cavity resonator integrated grating filters (CRIGF)

Second harmonic generation (SHG) is a second order nonlinear optical process corresponding to the creation, from a signal with a frequency ω, of a signal at frequency 2ω. SHG finds applications in nonlinear signal data storage, bio-imaging, straight frequency conversion for lasers...

The SHG phenomenon occurs under particular conditions and for a suitable choice of materials and configurations. In particular, a phase matching condition between the waves at ω and 2ω is required, together with a field enhancement. It was pointed out fifteen years ago [1], that guided mode resonance gratings (GMRG) can provide both field enhancement and a quasi-phase matching, and thus SHG enhancement. A GMRG is composed with a planar waveguide on which a sub-wavelength grating is engraved. For suitable incidence parameters, an eigenmode of the structure can be excited by the incident wave through an evanescent diffraction order of the grating, thus leading to a resonance phenomenon and an enhancement of the field. Even greater field enhancement might be obtained by surrounding the GRMG with two Bragg gratings, as proposed recently with the so called cavity resonator integrated grating filter (CRIGF) [2]. Hence, CRIGF are potentially interesting for SHG.

The Institute Fresnel has a huge experience in periodic structures and SHG modelling [3,4], and thanks to our recent project on CRIGF, we gain a deep physical understanding of this structure, and experience in its modelling [5,6].

The internship will consist in the theoretical and numerical modelling of SHG in CRIGF. In particular, we are interested in confirming the possibility to model it with our home made numerical programs, and to identify some potentially interesting configurations.

The candidate is expected to have basic knowledges in optics, and an interest for the numerical modelling of physical phenomena. The work made during the internship may lead to a more complete study of the SHG in CRIGF, during a PhD thesis, including experimental realizations in collaboration with an experimental team in Toulouse. **European citizenship is required.**

[1] *"Mode matching for second-harmonic generation in photonic crystal waveguides"*, A. R. Cowan and J. F. Young, Phys. Rev. B, **65**, 085106 (2002)

[2] *"High angular tolerance and reflectivity with narrow bandwidth cavity-resonator-integrated guided-mode resonance filter"*, Buet, X. and Daran, E. and Belharet, D. and Lozes-Dupuy, F. and Monmayrant, A. and Gauthier-Lafaye, O., Opt. Expr. 20, 9322-9327 (2012)

[3] *"Gratings: Theory and Numeric Applications"* (2012, éditeur E. Popov), www.fresnel.fr/numerical-grating-book

[4] *" Surface-enhanced second-harmonic generation in nonlinear corrugated dielectrics: new theoretical approach"*, J. Opt. Soc. Am. B, 11, 1555 (1994)

[5] *"Waveguide mode in the box with an extraordinary flat dispersion curve"*, J. Opt. Soc. Am. A, 32, 420-430 (2015)

[6] *"Numerical modeling of long sub-wavelength patterned structures"*, Opt. Quant. Electron., 47, 3171-3180 (2015)

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