Second harmonic generation (SHG) from resonant GaAs gratings

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We study SHG in nonlinear (NL), GaAs gratings. We find large enhancement of conversion efficiency when the pump field excites the guided mode resonances (GMRs) [1] of the grating. Under these circumstances the spectrum near the pump wavelength displays sharp resonances characterized by dramatic enhancements of local fields and favorable conditions for second harmonic generation, even in regimes of strong linear absorption at the SH wavelength thanks to the phase-locked (PL) component of the SH [2]. In particular, in a GaAs grating pumped at 1064nm, we predict SH conversion efficiencies approximately *five orders of magnitude* larger than conversion rates achievable in either bulk or etalon structures of the same materials [3]. In Fig.1a) we sketch the geometry under consideration and in Fig.1b) we calculate the forward SH conversion efficiency $\eta = P_{SH} / P_{FF}^2$ as function of the grating thickness W and compare it with the conversion efficiency of a bulk GaAs and with the conversion efficiency of an etalon GaAs placed in vacuo. The pump field incident at 10^0 on the grating is TE-polarized and the generated SH is also TE-polarized. This is a typical experimental configuration for SHG in GaAs [2].

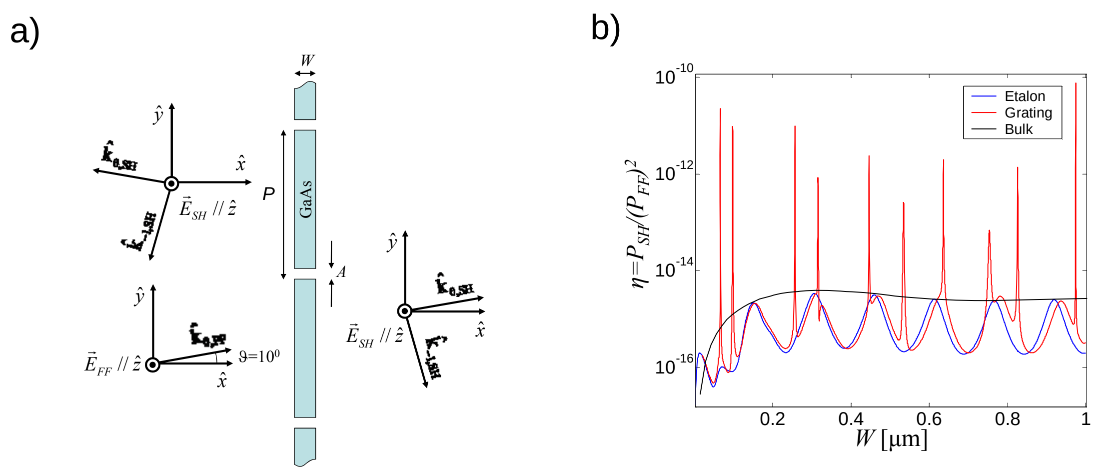

Fig. 1 (From [3]) a) Sketch of the pump signal incident at $\vartheta=10^0$ on the grating. The grating is subwavelength for the pump field (1064nm), while the diffracted SHG is distributed on the zeroth order at $\vartheta_{0,SH}=10^0$ and the first order at $\vartheta_{-1,SH}=-63^0$ in the case of a grating with period *P=500nm*. b) Normalized forward SH conversion efficiency of the grating, the bulk and the etalon structures as a function of thickness (*W*). The grating period is *P=500nm* and the slit aperture is *A=32nm*.

The nature of the enhancement is related to the strong field localization available for the pump field at the GMRs. At the same time material absorption at the SH wavelength plays no role in the NL interaction, and similar conversion rates are possible for either thin (see the peak at W~66nm) or thick structures (see the peaks at W>0.5μm). In the same vein we observe that GaAs may be replaced with any other quadratic NL material with similar results. The choice of different filling factors or slit sizes will merely shift the spectral positions of GMRs without altering conversion efficiencies. In this talk we will further discuss the physics behind the dramatic enhancement of the SH conversion efficiency pointing out how the unique combination of the properties of the PL-SH with the properties of the GMRs may pave the way to a new class of efficient, nano-sized, frequency converter devices in spectral regions otherwise considered inaccessible because of high linear absorption and/or poor phase matching conditions.

References

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