

8. Conclusions

We have performed a study of second and third harmonic generation in semiconductor- and dielectric- filled silver gratings, in the EOT regime. We find that using a $2\text{GW}/\text{cm}^2$ pump it is possible to achieve conversion efficiencies of 10^{-6} and 10^{-3} for SHG and THG, respectively, in regions dominated by FP cavity resonances at the pump wavelength, and by absorption at the harmonic wavelengths. A phase-locking mechanism binds the harmonics to the pump field and creates conditions that allow SH and TH fields to resonate despite the large nominal absorption. Plasmonic phenomena are unimportant to the process, and do not seem to offer an alternative to the sort of efficiencies that we predict by exploiting field enhancements in more traditional cavity environments. We have analyzed the interaction in two dimensions, by including surface and volume nonlinear phenomena in both metal and semiconductor sections of the grating, by considering different types of $\chi^{(2)}$ tensors, and by allowing the metal to display a $\chi^{(3)}$ response. We have shown that it is possible to trigger a novel down-conversion process that can re-generate phase-locked pump photons of polarization orthogonal compared to the incident pump field, i.e. a nonlinear polarizer of sorts. $\chi^{(3)}$ contributions and electron pressure within the metal can play relevant roles by boosting and/or shifting linear and nonlinear spectral features of the array. Further improvements to the individual conversion efficiencies are possible, especially for THG, by using metals like copper. If indeed $\chi_{Cu}^{(3)} \sim 10^{-6}$ esu, then a few tens of MW/cm^2 may suffice to begin to deplete the pump, within the limits imposed by inevitable band shifts arising from self- and cross-phase modulation. Both qualitative and quantitative aspects of the nonlinear response are promising, considering that typical material thickness is far smaller than the coherence length of the nonlinear crystal, and confined to deeply sub-wavelength slits.