Efficient Harmonic Generation in a Plasmonic System

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Abstract: As the first step toward parametric amplification of surface plasmon polaritons (SPPs), we demonstrate an efficient (nearly ~10^5 more efficient than previously reported) SPP-enhanced second harmonic generation in 2-methyl-4-nitroaniline (MNA) in a Kretschmann geometry.

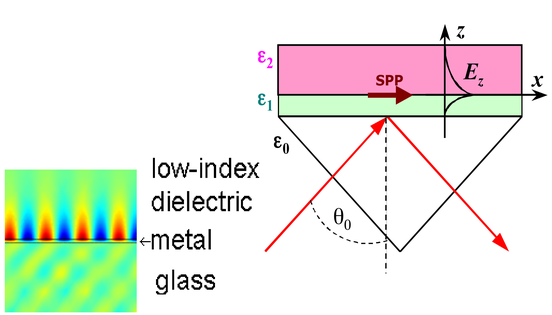
Introduction

Last decade has witnessed a burst of plasmonics and metamaterials research, with applications ranging from sensing to optical cloaking and sub-diffraction imaging.

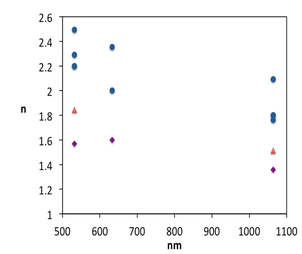
Optical gain in media with population inversion is one proven way towards active, amplifying and stimulated emission plasmonic systems. It is also a venue to so-much-needed low-loss plasmonics and metamaterials.

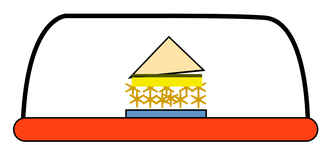
At the same time, optical gain is an inevitable source of spontaneous emission noise, which is undesired in information technology, imaging and many other applications.

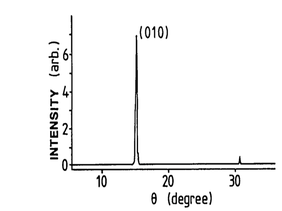
Nonlinear processes, such as frequency conversion and parametric amplification, are prospective noise-less alternatives to the optical gain.

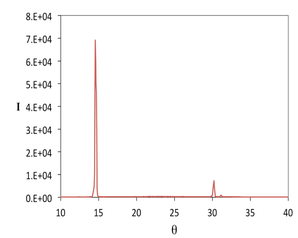


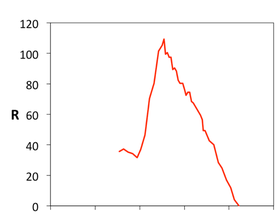
2-Methyl-4-Nitroaniline (MNA)

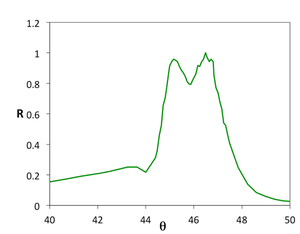


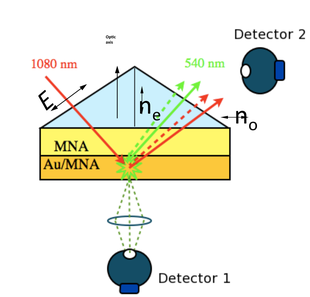


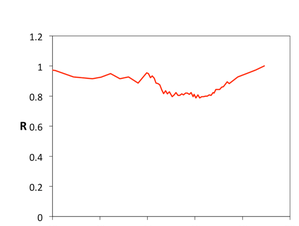




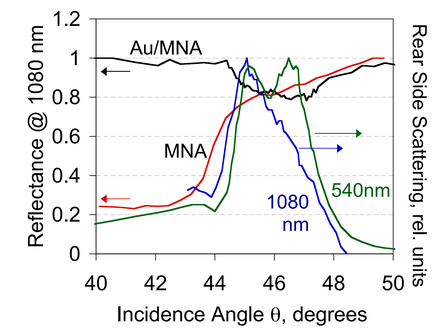


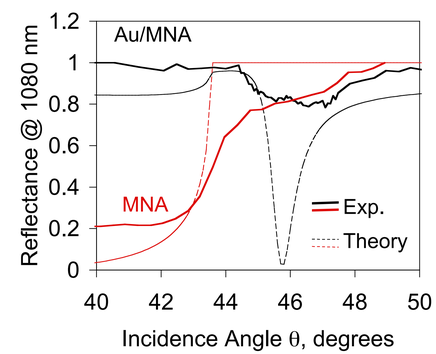


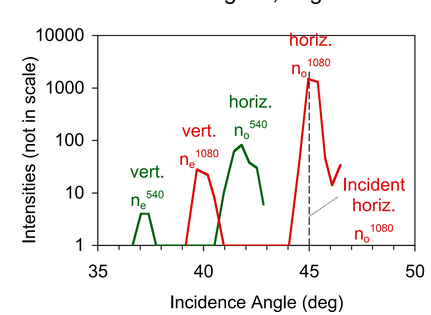




Characterization set up, Au MNA







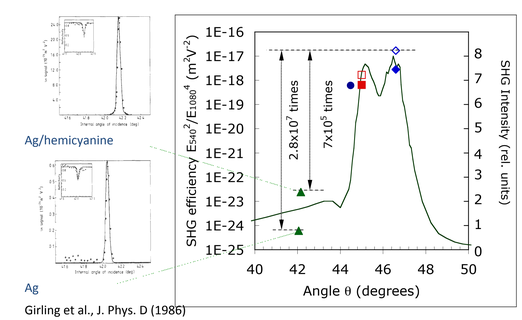
$$\frac{k_{incident}\sin(\theta_{incident})}{(\omega_{incident}/c)} = \frac{k_{outgoing}\sin(\theta_{outgoing})}{(\omega_{outgoing}/c)}$$

$$n_{incident}\sin(\theta_{incident}) = n_{outgoing}\sin(\theta_{outgoing})$$

$$n_o^{1080} = 2.47;\ n_e^{1080} = 2.73;\ n_o^{540} = 2.65;\ n^{540} = 2.93.$$

Conclusion

We have demonstrated an efficient second harmonic generation enhanced by surface plasmon polaritons in the Kretschmann geometry. Second harmonic beams propagated in the directions preserving tangential components of the photons' momenta. At λ=540 nm, the dielectric permittivity of MNA, ε=3.4, is sufficiently close to the absolute value of the dielectric permittivity of Au, ε=-5.7. Correspondingly, the second harmonic SPP, if excited, would decouple to the prism.



The ballpark estimate based on our second harmonic experiments as well as the data available in the literature, shows the parametric amplification coefficient in the Au/MNA system studied can be of the order of 10 cm^{-1}. The use of best performing $\chi^{(2)}$ material in combination with the femtosecond pumping and setup optimization can probably increase this value to 100 cm^{-1} but unlikely to 1000 cm^{-1}, still smaller than the gain, which can be provided by dye molecules of quantum dots.

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