Plasmonic lasing in periodic arrays of subwavelength apertures

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Abstract

Creating coherent light sources at the nanoscale has attracted great interest recently. The ability of surface plasmons –collective oscillations of conduction electron in metals— to confine light beyond the diffraction limit makes plasmonic structures ideal candidates for the development of practical nanolasers [1,2,3,4].

In this poster, we discuss our recent theoretical results on the dynamics of optical amplification and lasing action in periodic arrays of subwavelength apertures milled in opaque metallic films. We first introduce an *ab-initio* computational framework based on a finite-element approach, able to account for the time-dependent nonlinear interplay between the optical response of the gain medium and the plasmonic electromagnetic fields. Then, we apply this theoretical framework to a realistic structure formed by an opaque silver film perforated by a periodic array of slits and clad on each side by an optically pumped dielectric thin film containing Rhodamine dye molecules.

Our results show how the enhancement of the local electric field associated with the plasmonic resonances boost significantly the effective gain of the considered system. This enables, not only to achieve full-loss compensation [5], but also obtain self-sustained lasing oscillation. We also present a semiclassical microscopic description of the dynamics underlying the obtained lasing characteristics, together with a comprehensive analysis of the lasing features as a function of the relevant geometrical parameters defining the system. Finally, we discuss the application of our theoretical approach to provide the theoretical foundation of recent experimental results on plasmonic lasing action in metal hole arrays [6].

References

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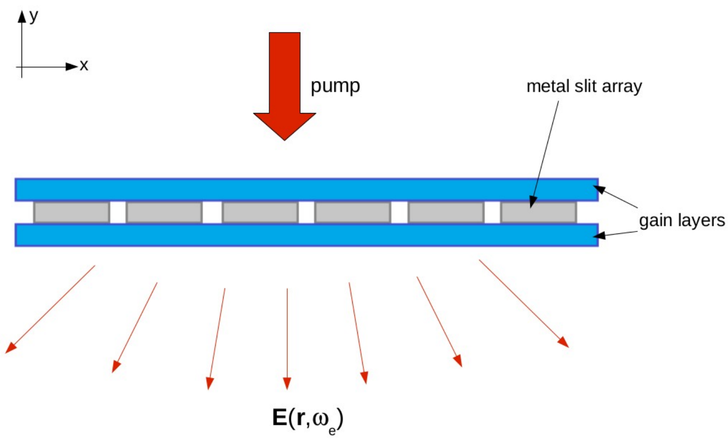
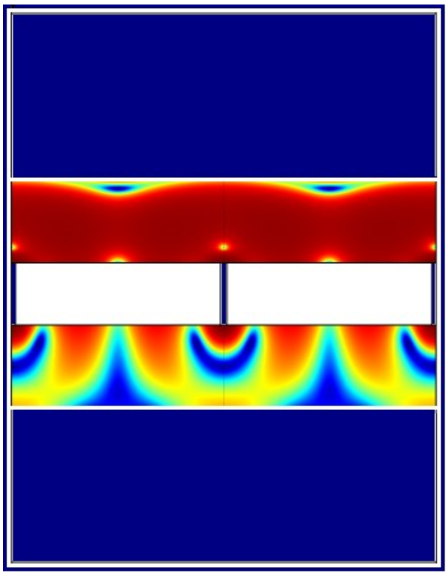
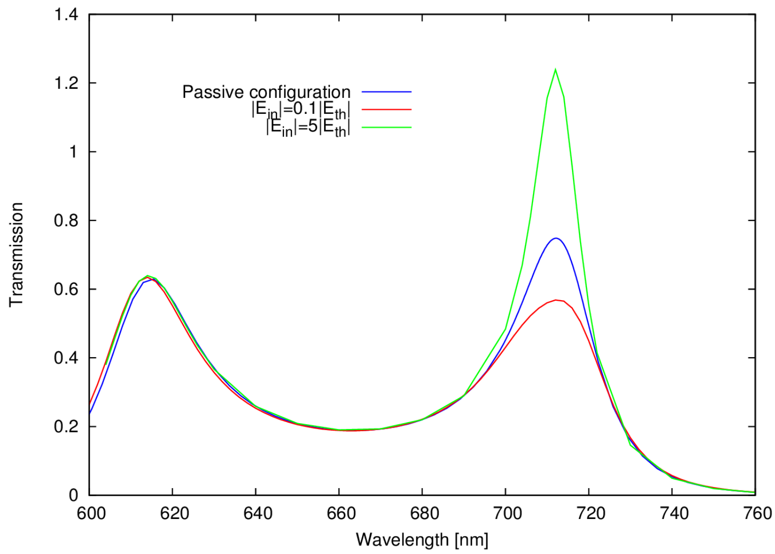


Figure 1: Subwavelength slit array structure studied.



(a)



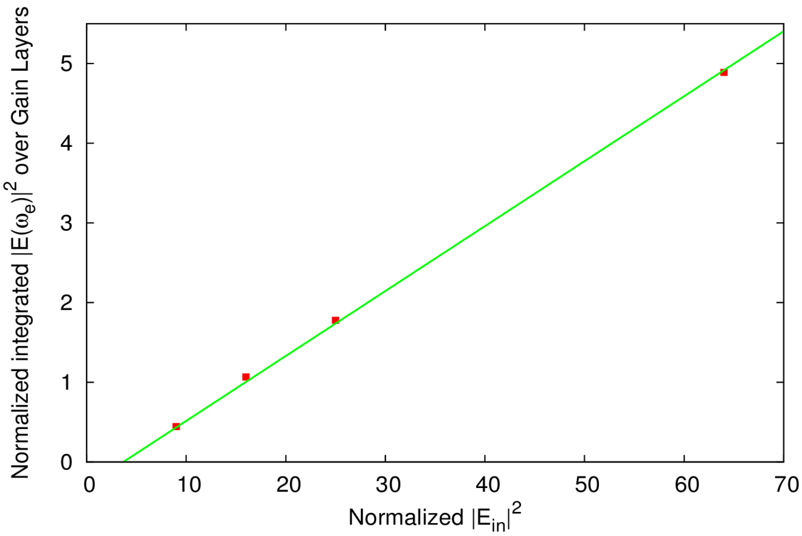
(b)

Figure 2:

(a) Spatial distribution of Normalized Population Inversion density in a slit array. Red (blue) accounts for the maximum (minimum) of the scale.

(b) Transmission spectra for various pump amplitudes. SP-resonance is enhanced (gain amplification regime) or depleted (absorption regime), depending on the value of the pump.

(c) Lasing regime is achieved for high enough pump. Lasing action shows up in linear emitted power vs. input pump power.



(c)