Electromagnetic Modeling of a Silver Nanostrip Laser Placed into an Active Cylinder

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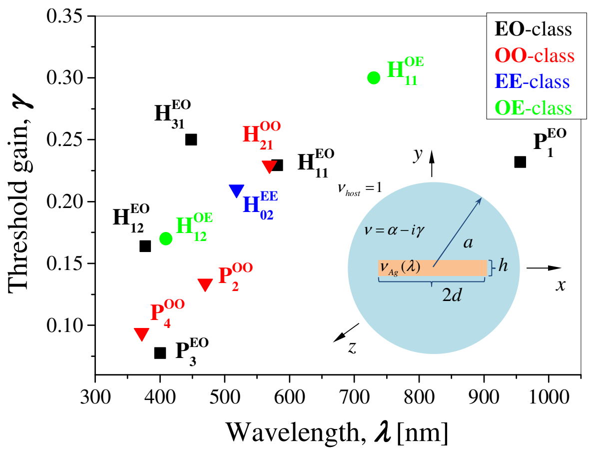
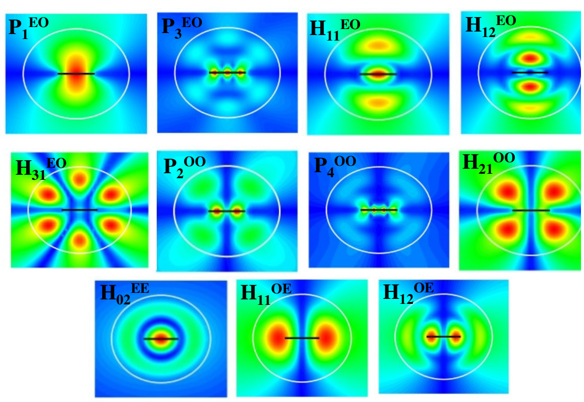
Recent progress in nanophotonics and nanoelectronics is greatly associated with understanding and use of resonance phenomena able to provide concentration of electromagnetic-wave power on nanoscale. This quest started quite long ago with the discovery of the localized surface plasmons (LSP) on metallic nanoparticles. Here, development of nanolasers based on LSP is important in the context of source light miniaturization for advanced nanophotonic and optoelectronic applications [1].

In this paper we present an accurate electromagnetic study of the lasing modes of a thin silver nanostrip placed into an active circular cylinder (shell). The corresponding 2D laser model is shown in the inset of Fig. 1(a). Assuming the lasing-mode frequency to be real-valued and following [1-3], the lasing eigenvalue problem is formulated in terms of pairs of real positive numbers (λ_s, γ_s), where λ_s is the wavelength and γ_s is the associated threshold value of material gain in the cylinder, introduced as imaginary part of the bulk refractive index. Due to the inherent two-fold symmetry, all modes split into four independent classes of symmetry with respect to the x and y-axes: *x-even/y-even case* (EE), *x-even/y-odd case* (EO), *x-odd/y-odd case* (OO), and *x-odd/y-even case* (OE). On imposing two-side generalized boundary conditions at strip's contour [4,5] and taking into account continuity of the tangential field components at the circle contour, we obtain four independent singular or hyper-singular integral equations on strip's median line. Finally, the use of the Nystrom-type discretization enables us to derive four independent characteristic equations, $\det|\mathbf{A}^{i,j}(\lambda,\gamma)|=0$ for each class of symmetry (i,j = E,O), and find their roots (λ_s, γ_s) numerically.

The obtained results show that considered nanostrip laser can emit light on several LSP modes of the even and odd orders P_s and also on the shell modes H_{mn} (see Figs. 1(a) and (b)).



(a)



(b)

(a) Lasing wavelengths and threshold gain values of the modes of four symmetry families EO (black), OO(red), EE (blue) and OE (green) for the strip of d = 100 nm, h = 20 nm inside the cylinder of the radius a = 300 nm. (b) Near-field portraits for the H-polarized lasing modes of a nanostrip laser.

References

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