Localized Extraordinary Optical Transmission through sub-wavelength apertures

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Introduction

Sub-wavelength apertures periodically arranged may transmit electromagnetic waves beyond the cut-off wavelength with a much higher intensity than if they were isolated. Confined electromagnetic modes at each side of a metal film may provide an efficient tunneling channel for photons passing through such array of holes. This is the so-called Extraordinary Optical Transmission **[1]**.

Results

We analyze theoretically resonances appearing at wavelengths beyond the cut-off of the holes **[2]**, **[3]**. We name this phenomenon Localized Extraordinary Optical Transmission (LEOT). Interestingly, no surface modes are involved; therefore, the physical mechanism is valid for both single holes (SH) and hole arrays (2DHA).
In particular, we will give analytical expressions for the LEOT peak position as a function of the film thickness (h), and the dielectric constants of the environment (the cover, the substrate, and inside the holes, ε_1, ε_3, ε_2, respectively) for both symmetric ($\varepsilon_1 = \varepsilon_3$) and asymmetric ($\varepsilon_1 \neq \varepsilon_3$) configurations, for any hole shape of high aspect ratio **(See Fig.1)**. Furthermore, the peak position is not the only spectral property affected by the dielectric environment, but also LEOT peak intensities are drastically modified.
These results explain the unexpected fact reported by recent experiments in the THz regime about enhanced transmission **[4]** through isolated holes at wavelengths red-shifted from the cutoff wavelength.

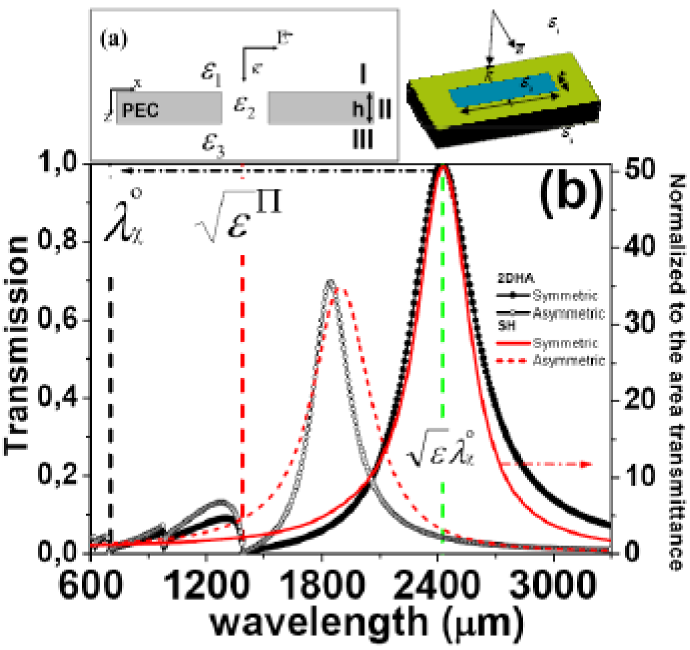

FIG.1: (a) Schematic of the investigated structure. Panel (b): for h = 1μm, rectangular holes with: a_x = 10μm, a_y = 350μm, and ε_2 = 1.0, the figure shows transmission curves through a 2DHA (P=400μm) placed in a symmetric environment (full symbols) and on a substrate (empty symbols). With solid line it is shown the normalized to the area transmission of a SH in the symmetric configuration. The dashed line depicts the same but for the asymmetric case. The dielectric constant of either the cover and/or the substrate is chosen to be 12.

References

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