Optimal Light Harvesting Structures in the mid Infrared

F. Villate-Guío[1], F. de León-Pérez[1,2], F.J. García-Vidal[3], and L. Martín-Moreno[1]

[1]Departamento de Física de la Materia Condensada and Instituto de Ciencia de Materiales de Aragón (ICMA), CSIC-Universidad de Zaragoza, E-50009 Zaragoza
[2]Centro Universitario de la Defensa, E-50090 Zaragoza
[3]Departamento de Física Teórica de la Materia Condensada, Universidad Autonoma de Madrid, E-28049 Madrid
fvillate@unizar.es

The ability of surface modes for squeezing visible light into metallic sub-wavelength apertures have being intensively investigated during last 10 years [1]. Efficient light harvesting (LH) structures have been proposed [2,3] and later used in the development of optical detectors, which can be integrated into standard optoelectronic devices [4]. The main goal of the present work is to translate the state of the art in LH technologies from the optical to the mid-IR regimen. As a first step into that direction, we study a typical LH structure: a sub-wavelength slit perforated in a corrugated metal film; see the inset of Fig. 1. Its IR response is computed with the coupled-mode method [1]. We show that the IR response of this 1D system can be optimized following simple design rules, based on physical intuition. Such optimal systems are next used as a seed for a conjugate gradient algorithm (CGA), which automatically scans the whole parameter space. Fig. 1 illustrates our results. It shows the spectra for a slit-grove array optimized with the CGA at a wavelength λ=4 μm. The back curve depicts the normalized-to-area transmittance (η) of a slit-groove array, where the single slit *i*s surrounded by 20 grooves. An efficiency of η=60 is obtained at λ=4 μm, which means that our LH structure is 60 times more efficient than a single slit. A further enhancement of 20% is achieved for a chirped structure (blue curve of Fig. 1).

References

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Figures

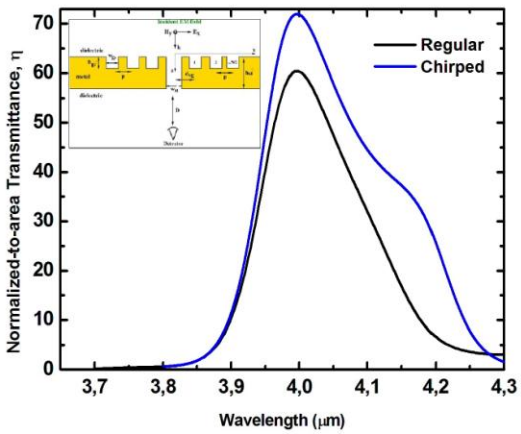

Figure1. Normalized to area transmittance for a slit-grooves array optimized at λ=4.0 μm. The efficiency of the regular structure described in the text is compared with a chirped slit-groove array (Slit: width=0.36 μm and depth=1.28 μm. Grooves: depth=0.5 μm, width=0.36 μm, and pitch=3.8 μm).