Light propagation and emission in hybrid metallodielectric systems based on self-assembled structures

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The fields of photonic crystals and plasmonics have been actively explored over the past two decades as a means to exert control on light propagation and emission in ways not permitted by conventional materials. While photonic crystals have achieved unprecedented control over the guiding and generation of light, the nanoscale confinement of electromagnetic radiation allowed by metallic nanostructured systems remains unparalleled. Recently, the possibility of combining the two fields in hybrid metallodielectric structures has paved the way to strongly confine electromagnetic radiation while avoiding losses associated with metals [1,2].

Over the past two years the potential of hybrid metallodielectric systems fabricated by means of selfassembly methods has been demonstrated through their use to strongly modify the spontaneous emission of internal light sources [3], as chemical sensors [4] or as a route to improve the efficiency of solar cells [5]. In this work we combine spectroscopic techniques together with k-space (Fourier) imaging [6] to characterize light propagation in this kind of structures. We have studied 2D arrays of organic spheres containing light emitters and considered first the role of the substrate in the light confinement capabilities of these systems (see Figure 1). [7] Further, a complete experimental study comprising dispersion relations together with equifrequency surfaces is presented and the way light coupled to or emitted from this kind of systems propagates within them is discussed (see Figure 2) [8].

References

[1] J. Grandidier, S. Massenot, G. Colas des Francs, A. Bouhelier, J.-C. Weeber, L. Markey, A. Dereux, J. Renger, M. U. González, and R. Quidant, Physical Review B 78 (2008) 245419.
[2] R.F. Oulton, V. J. Sorger, V. J. Zentgraf, R.M. Ma, C. Gladden, L. Dai, G. Bartal, X. Zhang, Nature 461 (2009) 629.
[3] M. López-García, J.F. Galisteo-López, A. Blanco, J. Sánchez-Marcos, C. López and A. García-Martín, Small 6 (2010) 1757.
[4] X. Yu, L. Shi, D. Han, J. Zi and P.V. Braun, Advanced Functional Matererials 20 (2010) 1910.
[5] J. Grandidier, D.M. Callahan, J.N. Munday, and H.A. Atwater, Advanced Materials 23 (2011) 1171.
[6] M. López-García, J.F. Galisteo-López and C. López, Submitted (2012).
[7] M. López-García, J.F. Galisteo-López, C. López and A. García-Martín, Physical Review B 85 (2012) 235145.
[8] J.F. Galisteo-López, M. López-García, A. Blanco and C. López, Langmuir 28 (2012) 9174.

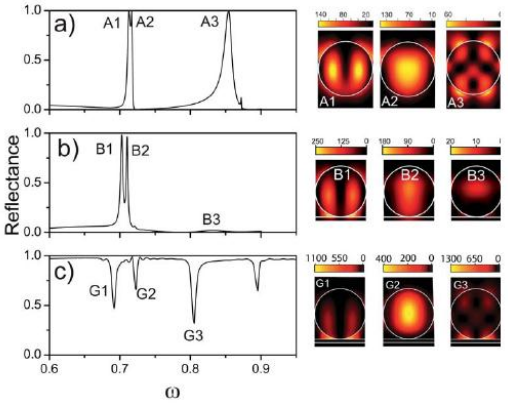

Figure 1: Calculated optical response of 2D hexagonal arrays of polystyrene spheres free standing (a) and deposited on dielectric (with refractive index 1.4) (b) and silver (c) substrates. Left column shows normal incidence reflectance spectra and right column shows total field intensity for different modes of the system.

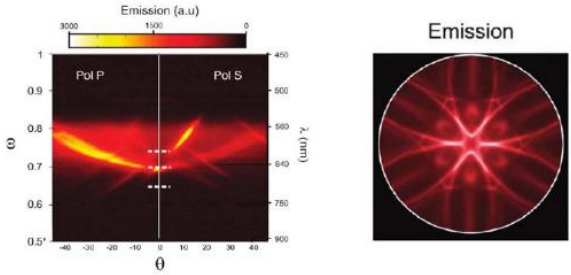

Figure 2: Angle and polarization resolved spontaneous emission measured for a hexagonal array of polystyrene spheres containing Rhodamine B and deposited on a silver substrate (left). Equifrequency surface collected in emission for a reduced frequency ω=0.7.