Rearrangement of the near-field landscape in heterogeneous nanoparticle arrays

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Geometric resonances in nanostructure arrays sustaining localized surface plasmons have received increasing attention in the last few years [1]. These geometric resonances exhibit narrower peaks than the purely plasmonic ones, therefore these systems are promising candidates for sensing applications [2]. Moreover, they provide new features in the near-field distribution patterns. Heterogeneous nanoparticle arrays offer a way to tune both the near and far-field response by using nanoparticles of different sizes, shapes or materials [3], but there is a lack of experimental studies in this context.

(a)

(b)

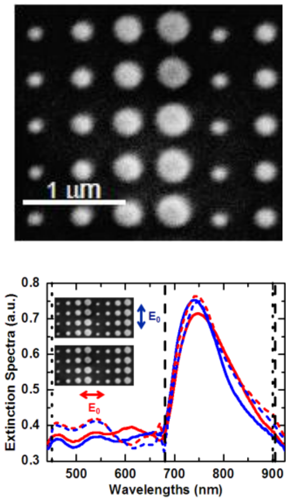

Figure 1: (a) SEM image of the studied sample, consisting of 120 nm height Au nanodiscs with four different diameters deposited on glass. (b) Experimental (solid lines) and numerical (dashed lines) extinction spectra; Inset: Polarization of the incident light.

In this work, we will present a theoretical and experimental analysis of the near-field modification induced by the presence of heterogeneity and collective resonances. We have investigated a two dimensional array of gold nanodiscs with four different diameters and located 3º off-axis (see Fig. 1 (a)), which also allows studying the effect of a small alteration in the geometrical arrangement [4]. We present zero-order extinction spectra acquired in far-field, as well as measurements of the near field distribution using SNOM technique in collection mode with two orthogonal polarizations and different wavelengths. Far and near-field characterizations are understood with the help of FDTD numerical results. The far-field spectra (Fig. 1 (b)) corroborate the existence of geometric resonances in our heterogeneous system, as predicted theoretically [3]. Moreover, from our numerical analysis it will be shown that heterogeneity has little influence on the far-field response. However, in clear contrast, the near-field shows a complex redistribution induced by the heterogeneity, as can be seen in Fig. 2. As illustrated in more detail by the simulated field maps of Fig. 3, the main effect is a dramatic break of the axial symmetry of the field pattern typically generated by nanodiscs, and more generally, the suppression or the enhancement of the field surrounding the nanostructures, mainly when the polarization is aligned along the heterogeneous direction. We attribute this to constructive and destructive interferences arising from the phase contribution of the field scattered from each kind of nanodiscs. Our results offer a deeper insight on the interplay between individual and collective resonances.

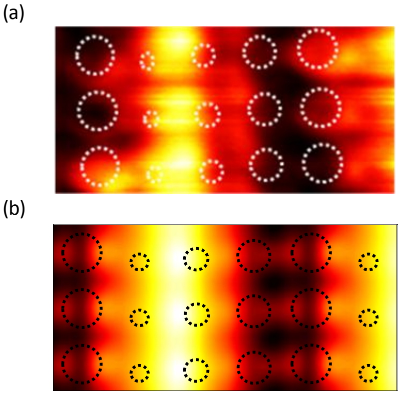

Figure 2: (a) SNOM image of the sample shown in Fig. 1(a). (b) Calculated distribution of the near-field. For (a) and (b) the wavelength is 860 nm and the incident polarization is aligned along the heterogeneous direction (represented with a red arrow in the inset of figure 1(b)). For (b) the near field distribution is calculated at an altitude similar to that of the SNOM scans, i.e. 100 nm above the nanodiscs.

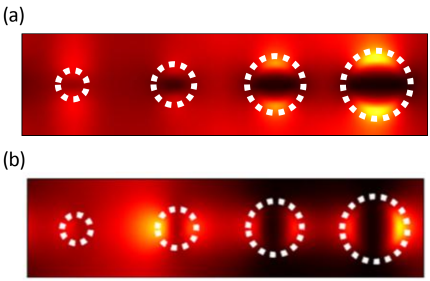

Figure 3: Simulated field maps at 860 nm wavelength for incident light polarized perpendicularly (a) or parallel (b) to the heterogeneous direction (blue and red arrows respectively in the inset of figure 1(b)). The field maps are calculated at 30 nm above the discs to show in detail the break of symmetry in the near field dipolar pattern when the polarization is aligned in the heterogeneous direction.

References

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