Enhanced and Tunable Magneto-Optcs *via* Fano Lattice Surface Modes in Arrays of Anisotropic Magnetic Nanoantennas

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Abstract

Recently it has been demonstrated that randomly distributed ferromagnetic nanoantennas (NAs) can jointly support Localized Surface Plasmons (LSPs) and Magneto-Optical Activity (MOA) when magnetized by an external static magnetic field [1]. Moreover, the dependence of the optical and MO responses on the antenna shape/size is further enriched when shape anisotropy of the NAs is exploited, which introduces resonance modes dependent on the incident light polarization [2]. Furthermore, ordered arrays of metal nanoparticles have been found to exhibit Fano-like resonances (called Lattice Surface Modes - LSMs), due to the interference between the inherent LSP resonances of the antennas and the narrow diffraction orders of the array [3].
In this work, we combine both the NA-shape anisotropy and the array arrangement to create magnetoplasmonic crystals with highly tunable optical and magneto-optical responses. We investigate the optical and magneto-optical properties of 2D square-arrays of ellipsoidal nickel nanodisks by means of electromagnetic simulations, via Coupled Dipole Approximation [4] and Finite-Difference Time-Domain [5] techniques, and state-of-the-art experiments. Our findings reveal a notable difference in the LSM behavior depending on whether the incident electric field is applied along either the long- or short-axis of the NAs. We show not only that the LSM behavior is spectrally tunable, but also that, by playing with the NA size and lattice periodicity, the optical and MO response can be actively tuned at wish, for instance, to achieve either transparency or enhancement of the MOA.
The results of our study show the advantages of combining anisotropic ferromagnetic metal nanoantennas with lattice diffraction, paving the way for the realization of a new class of highly tunable magnetoplasmonic nanodevices.

References

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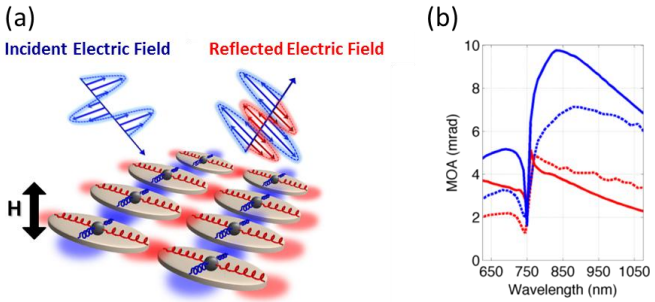

(a) Schematic illustration of periodic distributed elliptical nickel antennas immersed in a homogeneous medium, magnetized by an external static magnetic field H and hit by an external electromagnetic field E applied along the short axis of the NAs. The ferromagnetic nature of the NAs originates an electric field also along the long-axis. Both optical and magneto-optical responses are influenced by the surface lattice resonances due to the periodic pattern. (b) Experimental (dashed lines) and FDTD simulated (solid lines) MOA spectra for incident electric field lying along the long-axis (red-curves) and the short-axis (blue curve) of the antennas. The Fano-like feature appearing for both illuminations around 750 nm is the consequence of the interference between the antenna LSP and the array diffraction order.