Internal electromagnetic field distribution and magneto-optical activity of metal and metal-dielectric magnetoplasmonic nanodisks

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Localized surface plasmon resonances (LSPRs) greatly influence the optical [1-4] and magneto-optical (MO) [5-10] properties of fully metallic and metal-dielectric nanostructures. The observed enhancement in the MO activity when these LSPRs are excited is attributed to the high intensity of the electromagnetic (EM) field inside the global nanostructure when the LSPR occurs [5,11]. Unfortunately, it is not straightforward to experimentally determine the intensity of the EM field *inside* a nanostructure. Here we show how the EM profile related to the LSPR can be probed locally inside the nanostructure by measuring the MO activity of the system as a function of the position a MO active probe (a Co nanolayer). This will be done in full detail in metallic systems, and preliminary results will also be presented in more complex metal-dielectric magneto-plasmonic nanodiscs.

The magnetoplasmonic nanodisk arrays have been fabricated in large area onto glass substrates by combining colloidal lithography with sputter, thermal and electron beam deposition and lift-off techniques. Typical nanodisk structures are Au/Co/Au/Cr and Au/SiO_2/Co/SiO_2/Au/Ti, for the fully metallic and the metal-dielectric structures respectively, with total heights between 50 and 70 nm and diameters between 110 and 140nm (Figure 1(a)). For the sake of comparison, continuous thin films with identical composition have been also prepared.

The MO activity (Φ) has been obtained by measuring the MO Kerr effect in polar configuration upon normal incidence illumination, previously identifying the optical resonances through extinction spectra. In the fully metallic nanostructures, we find a distinctive evolution as a function of Co position of the MO activity in the nanodiscs compared with that of the continuous layers, with maximum values when the Co layer is located near the top or the bottom of the disks and minimum values in-between due to the LSPR excitation. This behavior is in contrast with the MO activity exhibited by the continuous films, which increases monotonously as the Co layer becomes closer to the top surface (Figure 1(b)). This indicates that the EM field inside the nanodisks exhibits a nonuniform distribution in plasmon resonance conditions. In fact, the Co layer acts as a probe sensing the EM field within the nanodisk, since the MO activity depends on the intensity of such field. Preliminary results on the possible influence of multiple resonances in metal-dielectric magnetoplasmonic nanodiscs will be also presented (Figure 1(c)).

This information could be very relevant for the design of magnetoplasmonic systems offering optimum MO enhancement, for instance for sensing applications where maximum sensitivity is expected in the areas with higher EM field.

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Figures

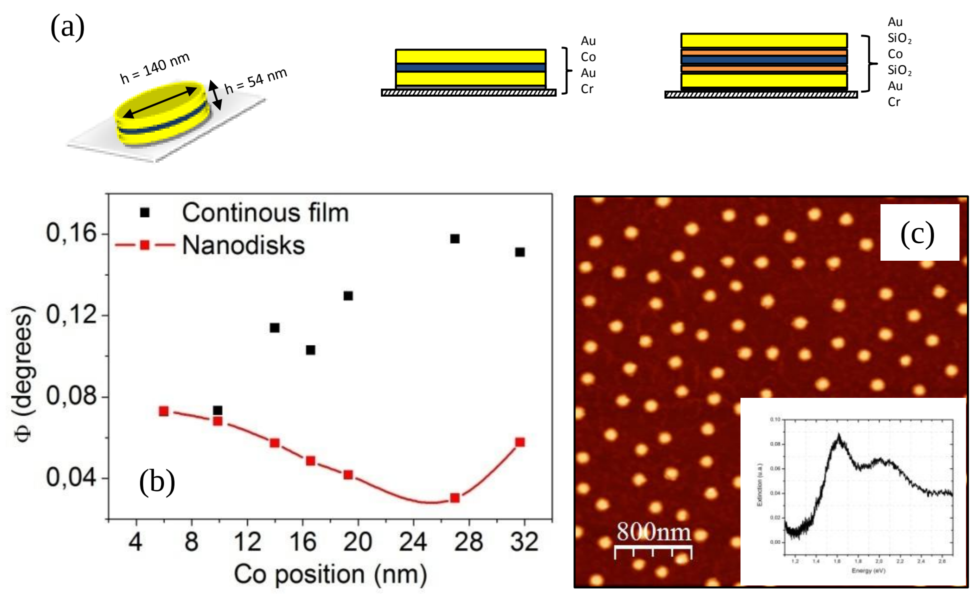

Figure 1: (a) Sketch of the fully metallic and metal/dielectric nanodiscs (b) Maximum magneto-optical activity as a function of the Co position for fully metallic continuous films and nanodiscs (c) AFM image of an array of metal-dielectric nanodisc array (Inset: extinction spectrum showing two characteristic peaks).