Coupling between localized surface plasmon resonance and magnetic properties of nanoparticles, the effect in the reversal process

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Magneto-optical (MO) techniques are well-established procedures to characterize the dynamics and reversal process of nanostructured materials and surfaces. At the same time MO properties include information on the band structure because MO effects are produced by the spin-orbit coupling. This interaction is largely modified in nanomaterials due to quantum confinement effects, changes in the electronic structure and surface contribution. Electronic plasmon excitations, typical of metal nanostructures, can also affect the MO response and the magnetic dynamics. Moreover the interaction between femtosecond light and magnetic materials can produce changes in the dynamic of the reversal process. As a consequence MO studies are emerging as fundamental methods to investigate the correlations between the magnetic, optical and electronic properties of nano-sized materials with an important role for understanding the possibility of manipulation of the magnetic information with light.

In our presentation we illustrate our research activity on the study on the interactions of the light with magnetic nanomaterials using magneto-optical techniques. We use a home-made magneto-optical set-up built around an optical cryostat with superconducting coils. This allows to measure the magneto-optical signal in the temperature range of 1.5 K to 300 K and with magnetic field of ± 5 T. We record the magnetic Circular Dichroism using beams with discrete wavelengths covering the 400 nm to 1000 nm range. We investigated the wavelength dependence of the MO hysteresis loops and the dynamics of of two families of alloy based nanoparticles: Co-Ni alloy nanoparticles prepared by sol-gel route [1] and Fe-Au nanoparticles prepared by ion implantation [2].

Co-Ni nanoparticles with different compositions have been investigated and in general they exhibit MO hysteresis loops larger of the magnetometric one (Figure 1) and mainly the coercive fields are wavelength dependent. The largest effect is observed in nanoparticles with composition Co33Ni66 in which the coercive field decreases from 0.25 T at 904 nm to 0.17 T at 400 nm being the magnetometric value 0.12 T. MO dynamic measurements confirm that near the UV, where Plasmon resonance can be excited in the metallic CoNi nanoparticles, the reversal dynamics is accelerated. Temperature dependence of the MO coercive field experiments exclude that the effect be related to the selectivity of the radiation at different ensemble of nanoparticles. In the case of Au-Fe nanoparticles with composition Au:Fe near SPR appears strongly dumped in the Vis-nIR spectral region due to the electronic hybridization of Au and Fe [3]. In fact pure Fe and AuFe nanoparticles present similar MO lineshape and extinction spectra due to the similarity electronic structure. However experiments made by recording the MO hysteresis loops with light at 632.8nm and simultaneously pumping with the Ar-laser line of 514 nm show one decreasing of the coercive field as function of the pumping power[4].

In both cases we observe changes in the reversal process due to the excitation of localized surface Plasmon excitation in the magnetic nanoparticles. The possible mechanisms and the correlation with the magnetic properties of the nanoparticles are discussed.

It unlocks the possibility of observing spin-plasmonic effects in the visible region, and thus opens a new area of fundamental research and interesting applicative possibilities in all fields requiring the mixing of spin and electronic properties, like magneto-optics, spintronics and spin-plasmonics.

References

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Figures

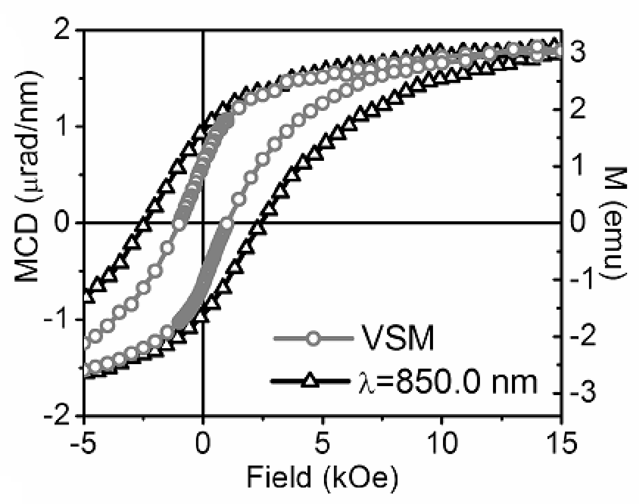

Figure 1. Hysteresis loops recorded by magnetometric (VSM) and MO measurements at 1.5 K.