MAGNETO-PLASMONIC MATERIALS: TUNING MAGNETO-OPTICS WITH PLASMONS

A. García-Martín, G. Armelles, A. Cebollada, J.M. García-Martín, J.V. Anguita, J.B. González-Díaz, J.F. Torrado, X. Bendaña and E. Ferreiro
Instituto de Microelectrónica de Madrid, Consejo Superior de Investigaciones Científicas, C\Isaac Newton 8 (PTM) 28760 Tres Cantos, Spain
antonio@imm.cnm.csic.es

During the last decades we have witnessed the development of a new branch in optics: plasmon optics or plasmonics. This comes from the need to develop optical components in the nanoscale and to overcome the restriction imposed by the diffraction limit. Plasmonics has already given rise to novel devices. However, in order to achieve the same state as conventional optics it will be necessary to produce active materials. These active materials are those whose optical properties can be controlled by an external agent. In our case the choice is a magnetic field. Here we will review our work on the combination of plasmons and magneto-optical activity. Firstly we will consider the system to consist in an ordered array of nickel wires and we will show that the excitation of a plasmon running along the wire gives rise to and enhancement of the magneto-optical response[1]. The use of ferromagnetic materials alone is not enough due to their broad plasmon resonance. However, the combination of magneto-optically active and noble plasmonic materials gives rise to systems with enhanced optical and MO responses. For instance, it has been shown that the MO response of Au/Co/Au trilayered systems can be enhanced when its surface plasmon resonance is excited [2], enabling to develop new high sensitivity biosensors [3]. It has also been demonstrated that an applied magnetic field modifies the propagation vector of the plasmon in continuous films[2]. However, such enhancement has been so far observed in continuous films, presenting simultaneously well defined propagating surface plasmon resonances and MO activity A discrete, nanostructured system exhibiting localized surface plasmon resonances (LSPR) may possess two mayor advantages with respect to continuous structures: the strong localization of the electromagnetic field associated to these resonances around the nanostructures (i) leads to a noticeable enhancement in the MO properties [4], and (ii) could be exploited to make such a system become a promising candidate for the development of high spatial specificity magneto-plasmonic sensing devices.

Complex onion-like nanoparticles made of noble metals and ferromagnets that exhibit LSPR have been obtained using different chemical methods [5], however no MO activity has today been reported. We will show that such active nanostructures exhibiting optical and MO properties can actually be obtained [4] using lithographic techniques. The system consists of Au/Co/Au nanodisks obtained from continuous Au/Co/Au films by colloidal lithography (see figure 1). This nanostructuration gives rise to strong changes in the optical absorption properties of the system. The absorption spectra of these disks present a characteristic peak around 2 eV. The peak is due to the excitation of the LSPR of the Au/Co/Au nanodisks and its energy position can be controlled by the nanodisk shape. This excitation affects the MO response of the system, leading to a net enhancement of the signal. This can be clearly seen in figure 2, where the total MO activity (defined as the modulus of the complex Kerr rotation) of the d=110nm nanodisks normalized to that of the continuous layers is depicted. The peak observed corresponds to that observed in the absorption spectra, illustrating the effect of the LSPR on the enhancement of the MO response.

References:

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Figures:

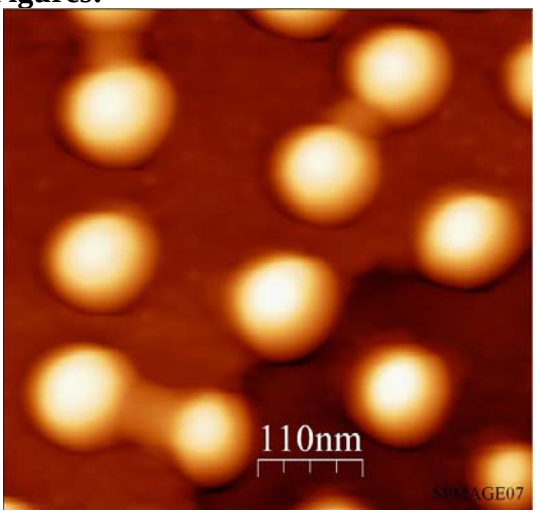

Figure 1. AFM image of the Au/Co/Au nanodisks fabricated by a colloidal lithography process.

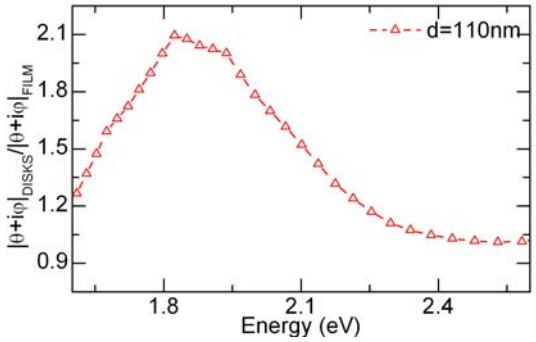

Figure 2. Total magneto-optical activity spectra for the 110nm diameter normalized to that of the continuous trilayer. An enhancement can be found at the same energy region of the plasmon resonance.