Magnetoplasmonics in Indium Tin Oxide Nanoparticles

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ABSTRACT

Magnetoplasmonics is a new emerging research field aimed at modulating the plasmon resonance through an applied magnetic field. Such a controlled magnetic modulation of localized surface plasmons resonance (LSPR) is extremely intriguing for the development of optical devices with improved performances, with applications spanning from telecommunications to refractometric sensing. The proper design of the composition and architecture of nanostructures is crucial to enhance the magnetic field modulation of LSPR. Within this framework, noble metal nanoparticles [1], nickel ferromagnetic nanodisks [2] or hybrid bimetallic nanostructures [3] have been proposed in the literature. A common drawback in the use of the above mentioned nanostructures is the introduction of high optical losses upon the incorporation of a magnetic metal.

In this work, 10 nm indium tin oxide (ITO) nanoparticles, a heavily doped semiconductor supporting LSPR in the infrared [4], are reported to have a 20-fold more intense magnetic modulation with respect to Au, as detected by Magnetic Circular Dichroism, while maintaining a sharp plasmonic response.

The enhanced magneto-optical response can be ascribed to the reduced free electron effective mass (m^*) of ITO with respect to most metals, which in turns boost the magnetic modulation. The latter is given in first approximation by the cyclotron frequency ω_C, which is inversely proportional to m^* and directly proportional to the applied field [1,5].

The use of MCD combined to extinction spectroscopy is also proposed here as powerful tool to easily extract free electron parameters, namely concentration and mass (N and m), in semiconductors, which is quite challenging for nano-sized particles. This approach was applied to a series of chemically synthesized quasi-spherical ITO NPs with Sn doping ranging from 2.5 to 15%.

Moreover, we performed a step forward toward applications by designing a proof of concept refractometric experiment, in which we measured the MCD spectra of 10% Sn-doped ITO NPs in different refractive indexes environments. The obtained sensitivities in terms of refractive index units are close to the current state of the art of refractometric sensing using LSPR in extinction spectroscopy [6].

In our opinion, our findings strongly impose heavily doped semiconductor nanoparticles as a new promising and intriguing material for magnetoplasmonics.

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