Magnetic modulation of surface plasmon modes in magnetoplasmonic Metal-Insulator-Metal cativies

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An external magnetic field is able to modify the properties of surface plasmon polaritons (SPP); in particular, when applied parallel to the interface but perpendicular to the SPP propagation direction, it modifies the SPP wavevector and introduces non-reciprocity in the dispersion relation [1]. This property has been known since the early '70s, but in the last decade it has received a renewed attention due to its potential for the development of integrated photonic devices, such as modulators [2] or optical isolators [3], as well as magneto-optical SPR sensors with increased sensitivity [4]. So far, the most often analyzed configuration consists of a single metal-dielectric interface where a magnetic element is introduced to increase the magneto-optic response, namely a ferromagnetic metal in a metallic noble metal/ferromagnetic metal multilayer [2,5-7] or a ferromagnetic dielectric [3,8]. However, very few studies have been devoted to more complex configurations composed of interacting interfaces.

In this work, we present, both experimentally and theoretically, the analysis of the magnetic modulation and non-reciprocity effects for the surface plasmon modes sustained by a metal-insulator-metal (MIM) cavity. The designed magnetoplasmonic MIM cavities consist of two metallic multilayers of Ag or Ag/Co with a SiO_2 spacer of different thickness. All upper metallic multilayers are capped by a thin Au layer to prevent oxidation. Three series of MIM cavities have been analyzed: with only one Co layer in the bottom metallic barrier, Co_{down}; with only one Co layer in the top metallic barrier, Co^{up}; and with one Co layer in each barrier, 2xCo (see sketches in Figure 1). As MIM cavities are known to support two modes, symmetric and antisymmetric [9], we have analyzed the magnetic modulation for each mode as a function of the thickness of the SiO_2 spacer for the three series. Figure 1 shows the obtained results. For only one Co layer present in the structure, a net modulation is observed, being it higher for the AM mode than for the SM mode. We attribute this to the difference in confinement between the two modes. For the 2xCo system, the modulation is reduced for both modes, mainly due to non-reciprocal effects.

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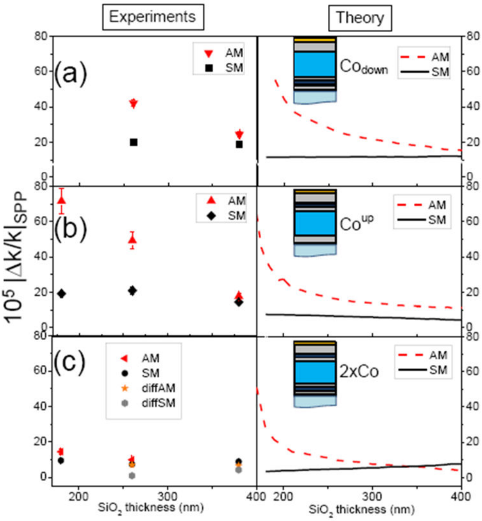

Figure 1: Experimental (left column) and simulated (right column) absolute values of the relative magnetic modulation of the SPP wavevector ($|\Delta k/k|_{SPP}$) as a function of SiO_2 thickness for antisymmetric, AM (red triangles and dashed lines) and symmetric, SM (black symbols and solid lines) plasmonic modes in (a) Co_{down}, (b) Co^{up}, and (c) 2xCo, magnetoplasmonic MIM cavities. The experimental $|\Delta k/k|_{SPP}$ values of the 2xCo series are also compared to the absolute difference between the Co_{down} and Co^{up} series modulation values for both modes (AM-star symbols, SM- hexagonal symbols) to establish the contribution of non-reciprocity.