FROM NANOLENTILS TO NANOCOLUMNS: TAILORING THE SHAPE OF METAL NANOPARTICLES BY PULSED LASER DEPOSITION

J. Gonzalo[1], J. Margueritat[1], C. N. Afonso[1], R. Marty[2], A. Arbouet[2], Ch. Girard[2]

[1] Laser Processing Group, Instituto de Optica, CSIC, Serrano 121, 28006, Madrid, Spain

[2] CEMES, CNRS, Université Paul Sabatier, 29 rue Jeanne Marvig 31055 Toulouse, France

j.gonzalo@io.cfmac.csic.es

The control of the size and shape of embedded structures within a few nanometers is one of the most challenging issues faced by nanoscience In particular, noble-metal nanoparticles embedded in a dielectric matrix have widely been studied during the last decade, since their unique optical properties make them promising materials for optical applications if a good control over the spectral response is achieved. The optical response of metallic nanoparticles is known to be dominated by an enhanced absorption at the surface plasmon resonance (SPR) wavelength that depends on the size and shape of nanoparticles. In the case of silver, the SPR is well separated from the absorption related to the interband transitions that eases the study of the dependence of the optical properties on NP morphological features such as size and shape.

In this work, we have successfully used pulsed laser deposition for embedding Ag nanoparticles in an amorphous Al_2O_3 host with controlled morphology. Nanolentils, nanospheres and nanocolumns oriented perpendicular to the substrate have been produced and this allowed us to study the relationship between the morphology and the surface plasmon resonance wavelength. Nanospheres have a diameter of 3.4 ± 0.2 nm, while nanolentils and nanocolumns have respectively diameters of 9.1 ± 1.0 nm and 2.7± 0.2 nm, and heights of 5.2 ± 0.2 nm and 7-65 nm. These values lead to aspect ratios of 0.6 and 2.5 to 25 for nanolentils and nanocolumns respectively.

Nanospheres are characterized by a single surface plasmon resonance in the extinction spectra, while the non-spherical shape of nanolentils and nanocolumns is evidenced through the presence of two absorption peaks corresponding to transverse and longitudinal SPRs. In the case of nanolentils, these peaks are respectively at higher and lower wavelengths than that of nanospheres, while the opposite occurs for nanocolumns. Although the results show clearly that SPRs are indeed tuned through the control of the aspect ratio, a detailed analysis of the optical response demonstrates that the number density of nano-objects also plays a significant role.