COMPLEX Ag-DIELECTRIC NANOSTRUCTURES PRODUCED BY PULSED LASER DEPOSITION

J. Margueritat*, J. Gonzalo*, A. Mlayah**, C.N. Afonso*

*Instituto de Óptica, CSIC, Serrano 121, 28006 Madrid, Spain

**Laboratoire de Physique des solides, Paul Sabatier Unviversity/CNRS, 118 route de Narbonne, 31062 Toulouse, France

E-mail: j.margueritat@io.cfmac.csic.es
http://www.io.cfmac.csic.es/GPL.html

When a metal nanoparticle (NP) is embedded in a dielectric host, the optical and electronic properties of the metal change completely due to the discretization of the energetic levels available to the system carriers [1]. The combination of this effect with those derived from its inclusion in a host, allow to *design new materials* with special macroscopic properties. In particular, the linear optical absorption increases at the characteristic wavelength of the surface plasmon resonance of the NPs (SPR). The fact that this behaviour is accompanied by a significant increase of the third order non-linear optical response ($\chi^{(3)}$),[1] makes them promising candidates for the development of integrated all-optical switching devices [2]. However, one of the major drawbacks for the development of practical devices is the lack of thin film synthesis methods with the required degree of control over the NPs morphology and distribution in the host.

In the past, we have successfully produced Ag NPs embedded in amorphous Al_2O_3 by alternate pulsed laser deposition with an excellent control over the metal concentration, NP dimensions and their in-depth distribution in the film.[3] However, the modification of the NP shape is limited by the coalescence of NPs in the plane, and this implies a non acceptable degree of absorption, making this control extremely difficult in practice. In this work we have produced complex structures by engineering the NP organization along the direction of growth, since in this case, the optical response of the nanostructures can be modified without an increase of absorption. We have reduced the distance between consecutive layers of NPs down to a value for which NPs are in contact. This approach has allowed us to modify the dimensionality of the produced samples: nanoparticles (0D)- nanowires (1D) – monolayers (2D) and therefore, the density of electronic states.

Optical absorption and low frequency Raman scattering have been performed in order to characterize the produced nanostructures. Their optical response presents a surface plasmon resonance that is related to the presence of Ag NPs with characteristic diameters in the range 2-3 nm as deduced from the frequency of the confined acoustic vibrations. As the distance between consecutive layers of NPs is reduced we observe a second peak in the optical absorption spectrum and a change in the intensity of the Raman spectrum. The results are discussed in terms of the interactions between NPs of consecutive layers and the transition from a one dimensional structure (nanowires) to a two-dimensional one (nanolayers).

References:

[1] C. Flytzanis, F. Hache, M.C. Klein, D. Ricard, Ph. Roussignol en “Nonlinear optics in composite materials”, Progress in Optics XXIX, Ed. E. Wolf, North Holland, Amsterdam, (1991).

[2] U. Kreibig, M. Vollmer en “Optical properties of Metal Clusters” Springer Series in Materials Science 25, Ed. Springer Verlag, Berlin-Heidelberg (1995).

[3] J. Gonzalo, R. Serna, J. Solís, A.Suárez-García, D. Babonneau, C.N. Afonso, J. of Physics D: Condensed Matter **15** (2003) S3001.