BIMETALLIC NANOPARTICLES PRODUCED BY PULSED LASER DEPOSITION

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Metal nanoparticles show special magnetic, electric, optical and catalytic properties. In particular dielectric films containing metal nanoparticles exhibit an enhanced absorption at the surface plasmon resonance (SPR) wavelength that can be used in optical applications, if a good control over the spectral response is achieved. It is usually claimed that this can be done through the modification of the nanoparticles size and shape. Nevertheless, the tuning range is very narrow and an increase in size leads in many cases to a non acceptable degree of absorption, making this control extremely difficult in practice. A different approach is the production of complex nanoparticles containing more than one metal. In this case, the physical properties can be tuned through the modification of the nanoparticle composition.

In the past we have succesfully produced single metal nanoparticles of Cu, Ag, Au, Fe or Bi embedded in amorphous Al_2O_3 by alternate pulsed laser deposition. This method is a single-step process, with excellent control over the metal concentration, nanoparticle dimensions and their in-depth distribution in the film. Thus, the production of bimetallic nanoparticles using alternate PLD can be considered as a natural step forward. In this work, we have extended this technology to produce bimetallic nanoparticles of composition Ag_XM_{1-X} with M= Cu or Au and X ranging from 0 to 1. These metals can form solid solutions (metastable in the case of Ag_XCu_{1-X}) over a wide compositional range, thus increasing the probability of producing bimetallic nanoparticles. They are embedded in an Al_2O_3 amorphous matrix by alternate ablation of pure metal and alumina targets.The structural analysis shows that nanoparticles with average diameter in the range 3-4 nm are produced in all cases, whereas the optical response of the nanocomposite films present a strong dependence on the metal composition. The SPR is found to broaden and redshift as the Ag content decreases and the Cu or Au content increases, the intensity of the absorption band being dependent on the total metal content. These results are much more evident in the case of Ag_XCu_{1-X} nanoparticles and moreover, the optical response is found to depend critically on the production sequence leading to different types of nanoparticles, namely alloyed, segregated or coated.

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