A study of the Near-Field of metallic materials for Plasmonics in the UV

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The last decade has seen an explosion in the development and exploitation of nanometer scale metallic structures because of their remarkable plasmonic ability to locally enhance electromagnetic fields and cross-section efficiencies [1-6]. The degree of enhancement strongly depends on the conductivity and geometry (size and shape) of the nanostructure. In the case of metallic nanoparticles, some of the plasmonic applications are based on the generation of Localized Plasmon Resonances (LPR's), whose spectral location and width are sensitive to their size, shape and optical properties as well as to those of the surrounding medium [7]. Visible and Near IR have been the most important spectral regions where Plasmonics has contributed to nanotechnology. However, UV deserves also some attention due to fundamental applications in biotechnology (bioimaging), Raman spectroscopy, device engineering and nano-material science [8,9]. Pursuing this objective, the aim of this research is to numerically analyze, by using the Discrete Dipole Approximation (DDA) method [10], the near field distribution shown in the UV by some metals like Magnesium, Titanium, Chromium, Tungsten, Ruthenium, Rhodium, Palladium, Platinum, Copper, and Indium, in order to find more possibilities in the UV. The plasmonic response of small hemispherical nanoparticles located on a dielectric substrate has been compared with others already characterized such as Au, Ag, Ga and Al [11].

The near field distribution is analysed on a hemispherical surface surrounding the nanoparticle. In order to do it properly, a mesh shell was made in the nanoparticle surface boundary. The electric field intensity was obtained for each intersection point in the mesh, and the average intensity over the particle surface was evaluated by assigning the appropriate weight to each point (given by $sin\theta$, in the inset of Fig. 1). For the incident wavelength for which the electric field enhancement factor is maximum [12], a typical dipolar field distribution is observed (Figure 1 for Mg) with high intensity lobes appearing close to the nanoparticle surface. Their centerline is shifted to an oblique direction due to both nanoparticle geometry and substrate effects. Usually, the highest intensity values are located on the boundary layer between the hemispherical particle and the substrate, and the hot spots are placed in the meeting point of the polarization plane, the substrate and the nanoparticle surface. Observing the spectral location and values of the near field maxima (Figure 2), and considering the electric field enhancement factor for a hemispherical particle of 20 nm radius, Mg, Al, Rh, Cr, Ru and Ti show LPR's in the UV range (3-5 eV), whereas for the rest of metals, they are located in the VIS range.

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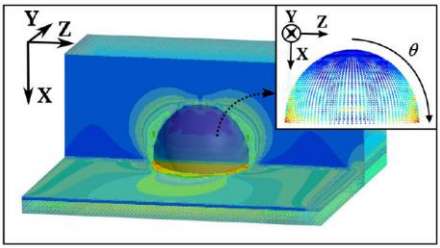

Figure 1: Near-field color map for a hemispherical Mg nanoparticle (R=20 nm) located over a sapphire substrate. Incident field Z-polarized.

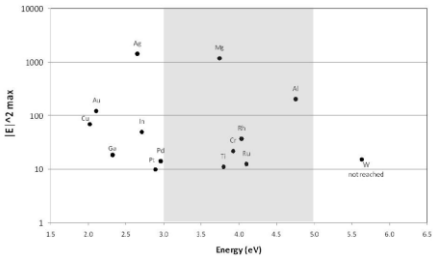

Figure 2: Maximum electric field enhancement factor ($|E|^2$ max) vs. energy values of the LPR for all the metals. The gray zone indicates the UV range (3 – 5 eV).

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