

# Effect of the oxide shell thickness on the UV plasmonic performance of Ga, Mg and Al nanoparticles.

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**Abstract**— A recent interest in UV-plasmonics has appeared due to its increasing potential in many applications ranging from biology, spectroscopy or engineering. Magnesium, Aluminum and Gallium have been pointed out as promising materials for this purpose. However, these metals form an oxide layer, several nanometers thick, that may affect the formation of localized plasmons. In this work we analyze how the oxide shell thickness affect the plasmonic performance of nanostructures made from these metals.

Plasmonics in the UV regime has awakened recent interest in fields such as biology, spectroscopy or nanosensing [1, 2, 3]. The plasmonic performance of various metals in the UV regime has been previously studied in order to find those more promising for UV plasmonics [4]. From this study those which were found to be more promising were Magnesium (Mg), Aluminum (Al), Gallium (Ga) and Rhodium (Rh). Although Rh does not oxidise, Mg, Al and Ga suffer from the formation of a several nanometer thick layer of oxide. The change in the surrounding properties affect the plasmonic behavior of the metal inside [5].

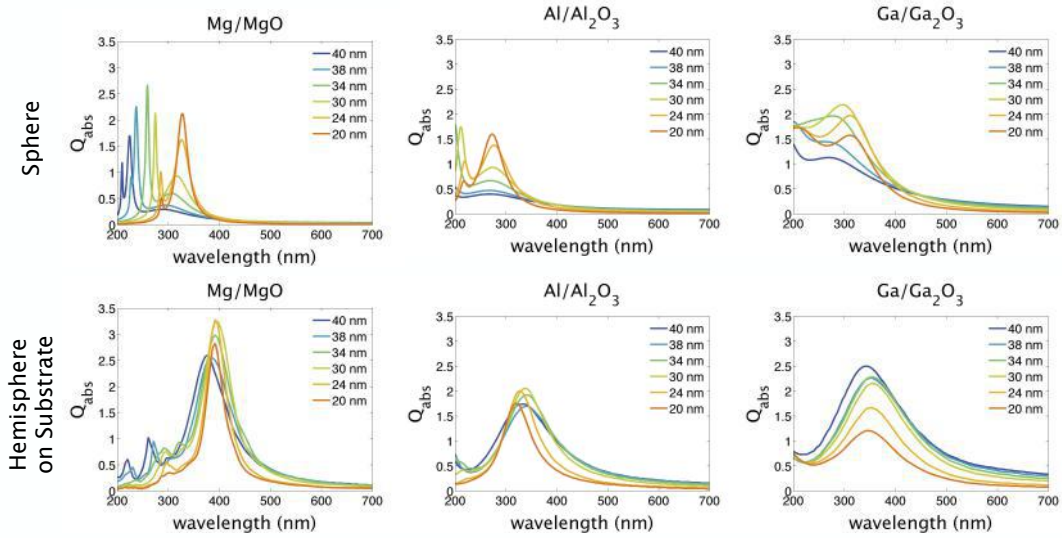


Figure 1: Absorption efficiency,  $Q_{abs}(\lambda)$ , of an isolated sphere (top) and hemisphere on substrate (bottom) NPs made of Mg, Al and Ga, all with radius  $R = 40$  nm, as function of the core radius,  $R_{core} = 20 - 40$  nm.

Two geometries have been studied: the isolated sphere and the hemispherical nanoparticle (NP) on a sapphire substrate, which represents the common experimental conditions for Mg and Ga [6]. Both near-field (intensity of the local field averaged over the NP surface  $I(\lambda) = \langle |E/E_{inc}|^2 \rangle$ ) and far-field (absorption efficiency  $Q_{abs}(\lambda)$ ) magnitudes have been analysed through this work.

From the results, it can be concluded that either a red-shift or a blue-shift of the resonance peak is produced depending on the material and the oxide layer thickness (see Fig. 1). The absorption efficiency of Mg and Al spheres increases as the oxide shell thickness increases. However, for the Ga sphere, the absorption efficiency maximum is produced for intermediate values of the oxide thickness, as for Mg and Al hemispheres. On the contrary, the Ga hemisphere increases its absorption efficiency as the oxide layer thickness decreases. In addition, the characteristic red-shift of the near-field,  $I(\lambda) = \langle |E/E_{inc}|^2 \rangle$ , with respect to the far-field,  $Q_{abs}(\lambda)$ , has been also observed. Further analysis will be introduced to give more insight on the subject. These results show both the importance of controlling the oxide contamination, and the possibility of tuning UV-resonances by means of oxide, or other non-metal coatings.

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