TiO_2/Au plasmonic nanocomposite for anti-reflection coatings

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Nanoplasmonics applied to photovoltaics is suggested as a promising strategy to increase short circuit photocurrent in solar cells, due to the enhancement of light absorption of the solar cell base material at resonant wavelengths with localized plasmons at noble metal nanoparticles (NPs) [1]. Applying a sol-gel method implemented with the spin-coating technique, one can synthesize Au NPs in solid Matrix Thin Films (MTF) of TiO_2 [2] and SiO_2 [3] on glass and Si(100) substrates, being this method easier, faster and lower cost than others.

The extinction coefficient spectrum shows a narrow band at around 2 eV (600 nm). If we increase the amount of gold present in the MTF the extinction coefficient intensity grows accordingly, as shown in Fig. 1. These spectra can be fitted (linewidth and position) by using the Mie scattering theory that takes into account the contributions of intra- and interband electrons [4,5]. With the parameters obtained from these fits and the Maxwell-Garnett effective-medium theory [6] we estimate the effective refraction index of the MTF deposited now on Si(100) and model the expected Reflectance under normal incidence of TiO_2 MTF as a function of the Au-NP filling factor (ration between the volume occupied by NPs and the total volume). By this way how the presence of Au NPs can affect the interferential behavior of the thin film Reflectance: a new minimum appears (and increase with the filling factor) on the short wavelength side of the NP Localized Surface Plasmon Resonance (LSPR), as observed in Fig. 2(a). This effect is also demonstrated experimentally, as shown in Fig. 2(b) for a MTF on silicon 90 nm thick (measured by SEM). This Reflectance minimum can be of interest in order to increase the light absorption in solar cells at the visible region, may be more useful in the case of crystalline and amorphous thin film solar cells.

References

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Figures

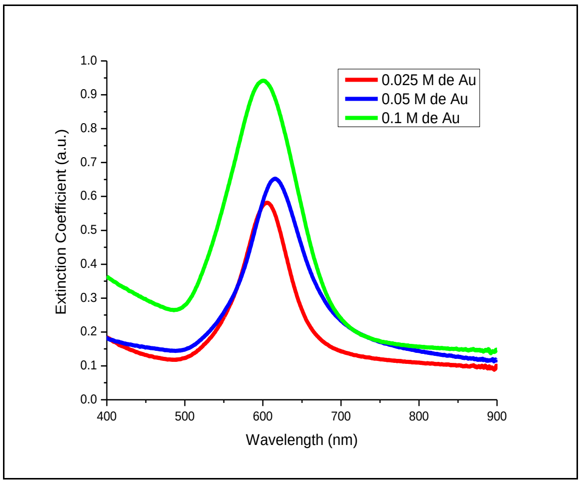

Fig. 1 Extinction coefficient spectra of TiO_2 MTF deposited on glass for different concentration of Au NPs.

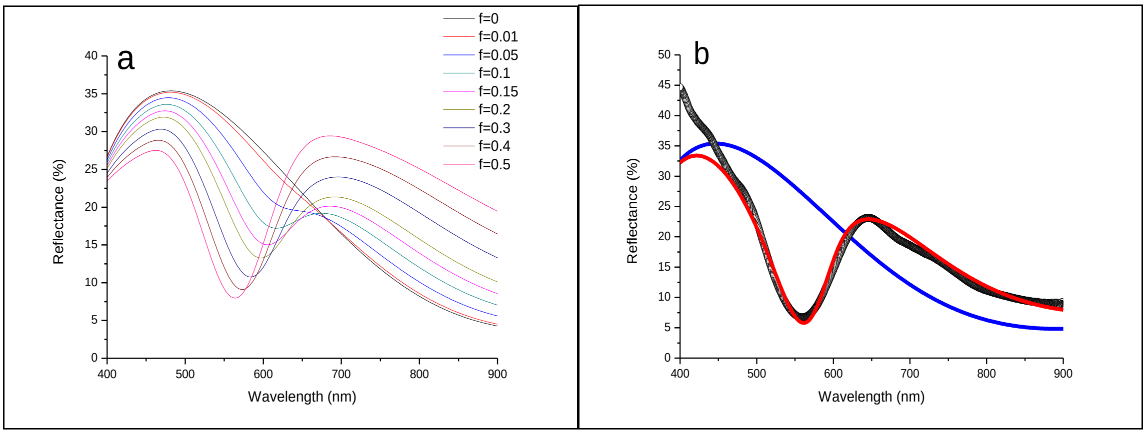

Fig. 2 (a) Reflectance of a 100nm thick TiO_2 MTF deposited on Si(100) as a function of the Au-NP filling factor, (b) Experimental reflectance for a 90 nm thick layer (black dots) with a best fitting curve using a filling factor of 0.2 (red line), in comparison to the calculated curve without nanoparticles (blue line).