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Microstructure and Ellipsometric Modeling of the Optical Properties of Very Thin Silver Films for Plasmonic Application

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Abstract. Excitation of surface plasmons in silver nanoparticles is a promising method for enhancing light trapping. The present paper shows results for the optical properties of the nanocrystalline silver thin films in attempt to understand the effects of the particle size. The influence of the substrate and post-deposition annealing in temperature range 150–500°C on the microstructure and optical parameters of thin films are traced.

The microstructure of the films was probed by scanning electron-microscopy (SEM), Atomic Force microscopy and X-ray diffraction (XRD). The size of crystallites/grains determined by XRD calculating from the Debye-Scherrer formula is in a good agreement with the AFM results. The Ag film with thickness up to 15 nm is found to be not continuous and to consist of aggregates of clusters. The heating of this film up to 300°C in argon atmosphere leads to the separation of clusters and forming of the spherical particles.

The optical properties were determined from spectral ellipsometric measurements. It was shown that the Drude-Lorentz model is suitable for characterization of porous films, while an island structure required modified Drude model with frequency dependent damping parameter, Γ_p. It was demonstrated that by appropriate selection of the deposition rate it is possible to vary the position of the maximum of the imaginary part of the dielectric function ε'' due transverse oscillation of the polarization of the silver grains in the range of 1.5–2.8 eV, while the resulting changes of the surface/volume ratio in reducing the grain size can shifts the maximum in the loss function $Im(-1/\hat{\varepsilon})$ from 3.8 to 3.5 eV.