Microstructure and ellipsometric modelling of the optical properties of very thin silver films for application in plasmonics

R. Todorov, V. Lozanova, P. Knotek, E. Černošková, M. Vlček

PII: S0040-6090(17)30184-0
DOI: doi: 10.1016/j.tsf.2017.03.009
Reference: TSF 35857

To appear in: *Thin Solid Films*

Received date: 30 March 2016
Revised date: 1 March 2017
Accepted date: 5 March 2017

Please cite this article as: R. Todorov, V. Lozanova, P. Knotek, E. Černošková, M. Vlček , Microstructure and ellipsometric modelling of the optical properties of very thin silver films for application in plasmonics. The address for the corresponding author was captured as affiliation for all authors. Please check if appropriate. Tsf(2017), doi: 10.1016/j.tsf.2017.03.009

Microstructure and ellipsometric modelling of the optical properties of very thin silver films for application in plasmonics

R. Todorov[1], V. Lozanova[1], P. Knotek[2], E. Černošková [3], M. Vlček [3,4]

1. *Institute of Optical Materials and Technologies "Acad. J. Malinowski", Bulgarian Academy of Sciences, Acad. G. Bonchev Str., bl. 109, 1113 Sofia, Bulgaria.*

2. *University of Pardubice, Faculty of Chemical Technology, Department of General and Inorganic Chemistry, Studentska str. 573, 532 10 Pardubice, Czech Republic*

3. *University of Pardubice, Faculty of Chemical Technology, Joint Laboratory of Solid State Chemistry of Institute of Macromolecular Chemistry of Academy of Sciences of the Czech Republic, v.v.i., and University of Pardubice, Studentska str. 84, 53009, Pardubice, Czech Republic*

4. Institute of Macromolecular Chemistry, Academy of Sciences of the Czech Republic, Heyrovskeho sq. 2, 162 06 Prague, Czech Republic

Abstract

Excitation of surface plasmons in silver nanoparticles is a promising method for enhancing light trapping. The present paper reports results for the optical properties of the nanocrystalline silver thin films in attempt to understand the effects of the particle size. The microstructure of the films was probed by scanning electron-microscopy, Atomic Force microscopy (AFM) and X-ray diffraction (XRD). The size of the crystallites/grains calculated from the XRD measurements by the Debye-Scherrer formula is in a good agreement with the AFM results. 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 the extended Drude model with frequency dependent damping parameter, Γ. It was demonstrated that the maximum of the imaginary part of the complex permittivity, $\hat{\varepsilon}(\omega) = \varepsilon'(\omega) + i\varepsilon''(\omega)$, that is due to the transverse oscillations of the polarization of the silver grains, can be positioned in the energy range of 1.5 - 2.8 eV in dependence of the deposition rate; it's been shifted to higher energies when reducing the grains size. Contemporary, the resulting changes in the surface/volume ratio lead to shifts the maximum in the loss function $Im\left(-1/\hat{\varepsilon}(\omega)\right)$ from 3.8 to 3.5 eV.

Keywords: very thin films, silver, spectral ellipsometry, plasmons.