Spectral and Morphology Analysis of Ultrathin Gold Films on Glass Substrate

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There are technical applications of gold where its optical properties are of great importance and can assist in solving the various problems. Among the problems is solar cell (SC) manufacturing with maximum light absorption in the cell working range. For thin film SC the gold nanoparticle array can be deposited on the top of photoactive layer to improve SC performance. The nanoparticles interact with solar light that result in light scattering and absorption. The light absorption peak position and sharpness depends on particle shape and size distribution. In the present work we studied technological aspects of gold ultrathin film deposition on optically uniform glass substrate with controlled film thickness up to 0,1 nm and the regimes of thin film annealing to produce nanoparticle array with satisfactory size distribution.

The glass plates of dimension 16x8x0,8 mm were used as substrate. The initial film deposition was carried out by vacuum magnetron sputtering in COM-TH2-SP2-ION device at temperature of substrate 323 K. Rate of deposition was equal to 0,7 Å/s. The thickness and deposition rate control was performed by quartz sensor SQC-330. The film thermal annealing was carried out in air condition for 2 hours at temperature T =683 K.

Optical spectra of absorption and transmission before and after annealing were measured independently by a fiber-optic spectrophotometer AvaSpec-ULS2048-UA-50 and two-beam spectrophotometer Shimadzu UV-3600. Maximum of light transmittance for deposited films is slightly shifted from approximately 485 nm to 510 nm with film thickness increase from 1 nm to 3 nm. The theoretical analysis of optical spectra was performed and optical constants of gold ultrathin films in visible light range in dependence of film thickness were determined. After annealing the absorption peak caused by plasmon resonance effect appears at wavelength about 530 nm. The peak is distinct for samples with initial film thicknesses of 2 and 3 nm, indistinct for 1 nm film, but its position is independent on initial film thickness. The surface morphology and nanoparticle size distribution were analyzed by electron microscopy method. The results of optical spectrometry and electron microscopy studies are discussed and theoretical curves for spectral extinction cross-sections for annealed films with different initial thickness are built.