Nanoplasmonics and surface enhanced spectroscopy

Development of films for plasmonic elements obtained using laser ablation of gold

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A promising direction of nano-plasmonics is creation of Surface Enhanced Raman Scattering (SERS) substrates and plasmon sensor nanostructures. Bearing it in mind, this work was aimed at development of two types of films allowing to fulfill conditions for propagation of surface plasmon-polariton (SPP) waves and to excite local surface plasmons (LSP). These films were formed using the method of pulsed laser deposition from the forward flow of particles leaving the erosion torch (first type) and from backward flow onto substrates placed into the target plane (second type). The gold target was irradiated with emission of YAG:Nd^{3+} laser (λ = 1.06 μm, E_p = 0.2 J, t_p= 10 ns, f_p =25 Hz) under control of the following technological parameters: gas pressure in the chamber (10^{-2}…10^{2} Pa), energy density in the pulse (5…20 J/cm^2), number of pulses (30000…60000). For the second type film, we also controlled the distance of the film part to the torch axis (5…20 mm). Morphology of film surfaces was studied using atomic force microscopy, while their porosity – using the method of X-ray reflectometry.

We have studied the influence of film formation conditions on the film thickness, sizes of gold nanoparticles (Au NP), pores and film porosity. It has been shown that the thickness of films lies within the range from several nanometers up to 50 nm. For the second type films, the thickness is comparable with sizes of Au NP and pores, and in film parts located near the torch axis it reaches 10 to 20 nm, far away – only several nanometers. Porosity of the first type films for gas pressure values lower than 10^{-2} Pa did not exceed 10^{-1} %, while for values close to 50 Pa it reached 30%. In the second type films, porosity lies within the range 30 to 70 %. These films were nanocomposite porous ones with Au NP arrays (por-Au).

The angular dependence of the intensity for the disturbed total internal reflection demonstrates SPP resonance observed in the first type film. The transmission spectrum shows LSP absorption in the film of the second type. The films were used for creation of plasmon sensor nanostructures and SERS substrates for Rhodamine R6G in the concentration 10^{-10} M and enhance factor $2 \cdot 10^{7}$.