Plasmonic Nanoporous Films with Gold Nanoparticles

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Nanocomposite porous films containing gold nanoparticles (Au NPs) (films of porous gold (por-Au) with porosity 5–60%) were formed using the method of pulsed laser deposition onto substrates which were placed both at a distance from the target (forward clusters transfer from the torch) and into the its plane (backward clusters transfer from the torch). The gold target was irradiated with emission of YAG:Nd^{3+} laser (λ = 1.06 μm, t_p= 10 ns, f_p=25 Hz) under control of the following technological parameters: gas pressure in the chamber $p_{Ar}=10^{-2}\ldots10^{2}$ Pa, energy density in the pulse j =5…20 J/cm^2, number of pulses N= 7500…60000, the distance from the torch axis to definite film area L =5…20 mm. Local surface plasmon resonance with maximum λ_{max}=540–740 nm was observed in transmission spectra T(λ) of films. The influence of formation conditions of film and its structure on the plasmon features was studied. Set of technological film preparation parameters with controlled plasmon properties LP was determined.

Forward clusters transfer from torch at $p_{Ar}\approx10$ Pa resulted in the formation of clusters with sizes of a few nanometers at high concentrations of ablation particles n_a. Films contain a large number of small size Au NPs with small spacing between them. This led to dipol-dipol interaction of Au NP which was responsible for T (λ) spectra at $\lambda_{max}\approx740$ nm. Argon pressure increase resulted in increasing of clusters size while concentration n_a was decreased. Films contain Au NPs of size up to 10-15 nm with less concentration and much large space size between them. Values λ_{max} in the visible spectra were connected with internal size effect in the dipole approximation, taking into account the impact of structural and electronic properties of Au NPs.

In backward clusters transfer from torch the films were obtained with gradient thickness, sizes of Au NPs, nanopores as well as with correspondent maximum in local surface plasmon absorption spectra.

Obtained por-Au films are designed to surface enhanced molecule fluorescence, quantum dots photoluminescence, Raman scattering. On the basis of these films SERS substrates were formed for Rhodamine R6G with concentration 10^{-10} M and enhancement factor $3.9\cdot10^{7}$. Great enhancement factor and the best analyte limit detection were achieved due to the nanoporous film structure which was characterized by “hot spots” formation.