Nanocomposites and nanomaterials

Post-deposition thermally driven formation and morphology of ultra-thin metal nanoparticle films

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Thin plasmonic metal films are important element of various photonic devices based on surface plasmon resonance (SPR) excitation. With resonance matching of the exciting light frequency and the frequency of surface plasmons, it is possible to reach a maximal increase of near-surface electromagnetic field together with corresponding enhancement of intensity of various photophysical phenomena.

In sensorics, relatively complicated excitation geometries are required in traditional SPR sensors with solid semitransparent metal (Au, Ag) films. The principal advantage of localized surface plasmon resonance (LSPR) sensing is the simplicity of plasmon excitation. LSPR properties are dependent on the morphology of discontinuous metal film (nanoparticle sizes, shapes, interparticle gaps) that it is able to fabricate plasmonic enhancing substrates with different resonance bands and sensing functions. Therefore the ability of LSPR frequency control is very desirable, especially in sensorics, SERS and SEIRA applications.

Typically, nanoparticle sizes and interparticle distances on a substrate are controlled during nanoparticle growth in wet chemical or electrochemical processes. In this work ultrathin gold nanoparticle films with mass thickness from 3 to 20 nm, thermally evaporated in vacuum on the glass substrates, were investigated. The morphology of these films was intentionally modified by post-growth annealing which caused optical properties change, especially in the region of LSPR excitation. Structure and morphology of films were examined with SEM and AFM techniques. Statistical analysis of nanoparticle sizes and interparticle distances shown that nanoparticle array characteristics, formed after thermal treatment, depend on initial film mass thickness, temperature and annealing duration. The conditions allowing fabrication of relatively narrow size distributed island films with average particle size from 15 to 60 nm have been determined.

These results are very important for many applications exploiting plasmonic field enhancement, notably in optoelectronics, photovoltaics and sensorics.