Plasmonic annealing of Ag nano-films under low ambient temperature

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Key words:
Ag nano-film; plasmon; annealing

Abstract

Plasmon effect as a phenomenon of nano-optics is generally considered to be a photon and electron collaboration oscillation on metal nanostructures and is attracted great attention for their unique properties[1-3]. When plasmon exciting on metal nanostructures, ~~the~~ localized photon energy is absorbed by the electrons with subsequent electron-phonon scattering resulting in the “heating” of metal nanostructures[4, 5]. This localized “heating” results in plasmonic morphology changes ~~in metal nanostructures~~ aroused great interest in nano-welding of metal ~~nanowires~~ nanostructures and have been applicated such as in human body targeted drug delivery and cancer treatments for their precise deformation position and tiny impact on surrounding environments[6-8].

Herein, plasmonic deformations of Ag nano-films on the surfaces of silicon and carbon spheres have been done, by using 800 nm, 30 W/ cm^2 illumination. Through measuring the plasmonic cumulative deformation on Ag nano-films with various thicknesses (range from 3 to 20 nm) both on the surfaces of silicon and carbon spheres, obvious agglomeration of nano-films into nanoparticles can be found on Ag nano-films with thickness lower than 10 nm. When the thickness is larger than 15 nm, no obvious deformation of Ag nano-films can be found after a long time illumination. Meanwhile, the increment of the ambient temperature is about 80 K from room temperature during the plasmonic deformation, which is much lower than the melting point of Ag nano-films. Detail works have been done to reveal the thickness depended plasmonic annealing of noble metal nano-films into nanoparticles under low ambient temperature. Theoretically, the surface electromagnetic field distribution has been carried out by FDTD methods. We found that plasmonic "hot spots" and elevation of surface energy on Ag nano-films cause the agglomerations of Ag nano-films into nanoparticles with thickness lower than 10 nm. And for the thicker ones, plasmonic "hot spots" and elevation of surface energy cannot provide enough energy for the atomic diffusion on Ag nano-film. ~~for the decrease of the surface energy of Ag nano-film~~.

In summary, although this annealing of Ag nano-films shows strong thickness dependence and only effective in Ag nano-films with thickness lower than 10 nm, but it can be predicted that it will be effective in greater scope of thickness after surface modifications. Therefore, the plasmonic annealing method exhibits as a simple and promising approach in metal nano-films annealing under low ambient temperature.

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