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ORIGINAL PAPER

Preparation of sterically stabilized gold nanoparticles for plasmonic applications‡

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Plasmonic nanoparticles such as those of gold or silver have been recently investigated as a possible way to improve light absorption in thin film solar cells. Here, a simple method for the preparation of spherical plasmonic gold nanoparticles in the form of a colloidal solution is presented. The nanoparticle diameter is controlled in the range from several nm to tens of nm depending on the synthesis parameters with the size dispersion down to 14 %. The synthesis is based on thermal decomposition and reduction of the chloroauric acid in the presence of a stabilizing capping agent (surfactant) that is very slowly injected into the hot solvent. The surfactant prevents uncontrolled nanoparticle aggregation during the growth process. The nanoparticle size and shape depend on the type of the stabilizing agent. Surfactants with different lengths of the hydrocarbon chains such as *Z*-octa-9-decenylamine (oleylamine) with $AgNO_3$ and polyvinylpyrrolidone with $AgNO_3$ were used for the steric stabilization. Hydrodynamic diameter of the gold nanoparticles in the colloidal solution was determined by dynamic light scattering while the size of the nanoparticle metallic core was found by small-angle X-ray scattering. The UV-VIS-NIR spectrophotometer measurements revealed a plasmon resonance absorption in the 500–600 nm range. Self-assembled nanoparticle arrays on a silicon substrate were prepared by drop casting followed by spontaneous evaporation of the solvent and by a modified Langmuir–Blodgett deposition. The degree of perfection of the self-assembled arrays was analyzed by scanning electron microscopy and grazing-incidence small-angle X-ray scattering. Homogeneous close-packed hexagonal ordering of the nanoparticles stretching over large areas was evidenced. These results document the viability of the proposed nanoparticle synthesis for the preparation of high-quality plasmonic templates for thin film solar cells with enhanced power conversion efficiency, surface enhanced Raman scattering, and other applications.

Keywords: metallic nanoparticles, gold, high temperature synthesis, small-angle X-ray scattering

Introduction

Metallic nanoparticles represent a very active field of research because of their potential applications in optical, electronic, and magnetic devices and as catalysts. In particular, it is very attractive to investigate optical properties of gold, silver, and copper nanoparticles because of their strong light absorption in the visible region due to the surface plasmon resonance (SPR) effect. The SPR wavelength depends on the size, size dispersion, and the shape of the metallic nanoparticles (Esumi et al., 2004; Mastiholi et al., 2013; Raikar et al., 2011). Aggregation effects and surrounding dielectrics play also an important

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