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Pulsed Electrodeposition of Gold Nanoparticles on Fluorine-Doped Tin Oxide Glass and Absorption-Based Surface Plasmon Resonance Evaluation

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Abstract. Synthesis and immobilization of Au nanoparticles (AuNPs) was performed on transparent fluorine-doped tin oxide (FTO) substrate by pulse electrodeposition method. The method was cost effective, simple and capable of producing nanoparticles strongly attached to the substrate. Effects of several influencing factors such as duty cycle, pulse frequency, current density, solution concentration, deposition period and annealing procedure on the optical properties of AuNPs-FTO electrode were investigated. AuNPs-FTO electrodes were characterized by X-ray diffraction (XRD), field emission scanning electron microscopy (FESEM), atomic force microscopy (AFM) and UV-Vis absorption analysis. Controllability of the plasmon absorption of the electrodeposited film by tuning of the electrodeposition conditions and thermal annealing procedure was important achievements helpful to the progress of the AuNP film applications in the tunable localized surface plasmon resonance spectroscopy (LSPR) manufacturing industry.

Introduction

Nowadays, AuNPs are increasingly considered for wide range of applications such as electronic sensors, catalytic devices, solar batteries and biosensors due to their superior conductivity, easy transfer of electrons, adjustable optical and electrical properties, biocompatibility and high catalytic effects [1-5]. Conductive substrates coated with AuNPs display excellent conductivity and electrocatalytic and electrochemical performances [1-8]. Improvements achieved must, however, be preserved by strong attachment of the AuNPs to the substrate without any undesirable aggregation [7]. The package can then be used as a noble electronic sensor, catalytic device, solar battery or biosensor [1,3].

In order to make AuNPs electrodes, transparent conductive films (TCF) can be used as supportive substrates. Typical inorganic examples are transparent conducting oxides (TCO) like Sn-doped indium oxide (ITO), fluorine doped tin oxide (FTO) and doped zinc oxide (ZnO). TCO-AuNPs electrodes have good transparency, desirable electrical conductivity, special chemical reactivity, high chemical stability and heterogeneous kinetics for the electron transportation. These properties provide high potentiality for many electrochemical and electrocatalytic applications [1,2].

TCO-AuNPs electrodes are usable in electrochemical measurements of biomolecules (e.g. uric acid) [9], non-linear optical devices [10], spectroscopic detectors and surface plasmon resonance spectroscopy [11]. AuNPs can increase absorption of the visible light (as a plasmonic material) and enhance the kinetics of interfacial charge transfer [12]. The origin of strong absorption peaks in the visible light is ascribed to the coherent oscillation of the electrons in the conduction band when induced by electromagnetic field [13]. Plasmonic resonance surfaces such as AuNP-TCOs are usable for fabrication of the inexpensive biosensors based on localized surface plasmon resonance (LSPR) using UV-Vis spectroscopy.

The surface plasmon resonance (SPR)-based optical properties are beneficial for evaluation of macromolecules, equilibrium affinity, enthalpy extent, kinetic swiftness, mutant proteins analysis, imaging and photovoltaics when measured in biosensors [14-16]. A major use of LSPR-shifting is