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Elevated surface plasmon resonance sensing sensitivity of Au-covered silica sphere monolayer prepared by Langmuir–Blodgett coating

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ABSTRACT

The colloidal Langmuir–Blodgett coating process is used to fabricate Au-covered silica sphere monolayer (Au film over silica nanosphere (AuFON)) and study the effects of silica diameter on surface plasmon resonance (SPR) sensing sensitivity. The resulting hexagonal close-packed (HCP) monolayers are prepared with silica sphere diameters of 200, 400, 700, and 1000 nm. In SPR sensing applications, the optical properties of Au-covered silica sphere monolayer are evaluated by measuring normal-incidence reflection spectra and sensing tests. The high sensitivity (nm/RIU) is observed in silica sphere diameter (1000 > 700 > 400 > 200 nm) and plasmon mode (dipole > Fano resonance (FR) > and high order) while the highest sensitivity is 968 nm/RIU (dipole mode, 1000 nm of silica sphere diameter). 3-D Finite Difference Time Domain (FDTD) simulation shows a sensitivity trend similar to the experimental results.

Introduction

Nanotechnology is being developed extensively and has made significant contributions in various scientific and engineering industries. As it is already well-known, materials fabricated at the nanoscale exhibit unique physical, chemical and catalytic properties compared to the bulk state [1–3]. A 70-fold higher adsorption coefficient (K_{ads}) of organic acids is observed on the surface of the 6 nm titania nanoparticle compared to a diameter of 16 nm [1]. The melting points of Au nanoparticles decreases significantly from 1064 °C (bulk state) to about 500 °C (particle diameter, 4 nm) [4]. These results may be explained by an increase in broken bonds of thermodynamically unstable surface atoms. After Faraday described the optical properties of metal nanoparticles, the unknown qualitative and quantitative optical phenomena could be expressed by the extreme wave control with the types of material, structures (size, shape, composition, and symmetry) and periodicity in the specific nanostructures [5–10]. The colloidal Au nanoparticles show rub/red or red wine color while the representative beautifully-lighted orange–yellow blend of the bulk Au surface is no observed at all [3,11,12]. This phenomenon is a result of strong broadband absorption (~530 nm of wavelength) on the surface of Au nanoparticles. The application of the colloidal Au nanoparticles is found in the stained glasses which is commonly installed in the historical religious architectures and Lycurgus dichloric glass cup [13–15]. Au nanoparticles are recently being introduced into chip-based surface plasmon resonance (SPR) biosensors for the applications in medical and life sciences while SPR is recognized as a simple and powerful direct technology through a label-free process [16–19]. A collective electromagnetic wave, surface plasmon at the interface between the metal electric and dielectric could be excited by compensation of wavevector difference with external light sources and it is quite sensitive to immediate dielectric changes [20]. Consequently, unique optical spectra are obtained with transmission, extinction, scattering, reflection and/or phase/angle distribution. Localized surface plasmon resonance (LSPR) can successively monitor the local

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