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Plasmonic Optical Fiber Sensor Based on Double Step Growth of Gold Nano-Islands

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Abstract: It is presented the fabrication and characterization of optical fiber sensors for refractive index measurement based on localized surface plasmon resonance (LSPR) with gold nano-islands obtained by single and by repeated thermal dewetting of gold thin films. Thin films of gold deposited on silica (SiO_2) substrates and produced by different experimental conditions were analyzed by Scanning Electron Microscope/Dispersive X-ray Spectroscopy (SEM/EDS) and optical means, allowing identifying and characterizing the formation of nano-islands. The wavelength shift sensitivity to the surrounding refractive index of sensors produced by single and by repeated dewetting is compared. While for the single step dewetting, a wavelength shift sensitivity of ~60 nm/RIU was calculated, for the repeated dewetting, a value of ~186 nm/RIU was obtained, an increase of more than three times. It is expected that through changing the fabrication parameters and using other fiber sensor geometries, higher sensitivities may be achieved, allowing, in addition, for the possibility of tuning the plasmonic frequency.

Keywords: optical fiber sensor; localized surface plasmon resonance; gold nanoparticles; gold thin film dewetting

1. Introduction

The measurement of the refractive index (RI) of liquid solutions brings information about its chemical and physical properties, as well as the composition and concentration of dissolved biochemical or biological substances [1]. There are several methods to measure the RI using either free space propagation or guide wave optics [2,3].

Optical fiber sensors (OFS) based on surface plasmon resonance (SPR) can be made with metallic thin layers on top of specific optical fiber surfaces, creating features highly sensitive to the surrounding medium [4–6]. In certain conditions, the fabrication of noble metal thin films with nanoscale patterns, usually gold (Au) and silver (Ag), leads to a buildup of the electromagnetic field at the nanostructures boundaries and the phenomenon of localized surface plasmon resonance (LSPR) may take place. This effect results in the appearance of absorption bands whose resonant frequency depends upon the size, shape, and composition of the nanoparticles (NP) and the surrounding RI [7–9], allowing label-free real-time RI measurements.

Several protocols have been developed to obtain Au NP with the chosen size and shape, dispersion stability and surface functionality. These methods can be classified either as physical or chemical [10–14]. However, while the physical methods require expensive equipment, the chemical methods are laborious and often lead to non-uniform films. The thermal annealing of metal thin