

Effect of Particle Size Distribution on the Refractive Index Sensitivity of Plasmonic Nanoparticles

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Summary:

Numerical simulation was used to investigate the extinction cross-section and bulk refractive index sensitivity of size-distributed gold and silver nanoparticles. Spherical and cube-shaped particles have also been studied. The results confirmed that the optical properties and bulk refractive index sensitivity of these nanoparticles are significantly influenced by their size distribution. If the particles are more uniform, this results in higher sensitivity.

Keywords: bulk refractive index sensitivity, size distribution, localized surface plasmon resonance, simulation

Background, Motivation and Objective

One of the most important applications of localized surface plasmon resonance is the use of the phenomenon to make sensors [1]. In general, one tries to describe a given nanoparticle system by simulating a single typical particle. Therefore, there is a large literature on how the shape or material of a particle affects its optical properties. In reality, however, it is not possible to make an accurate model with a single particle. The size distributions of nanoparticles generally follow a log-normal distribution [2] and the size distribution of particles in a solution has a significant effect on its optical properties [3]. The aim of this article is to show how important the often neglected size distribution really is.

Description of the New Method

The synthesis method used significantly influences both the mean value and standard deviation of nanoparticle size. However, within a given method, these variables are not independent of each other. The simulations were evaluated based on the simple but useful assumption that the mean value and standard deviation are proportional to each other. This assumption is supported by experimental data [4].

Results

In this study, the extinction cross-section and bulk refractive index sensitivity of size-distributed gold and silver nanoparticles, both

spherical and cubic, were investigated using the finite element method. The research showed that these properties are significantly influenced by the size distribution of the nanoparticles. A lower standard deviation in the distribution results in higher sensitivity. (see Fig. 1).

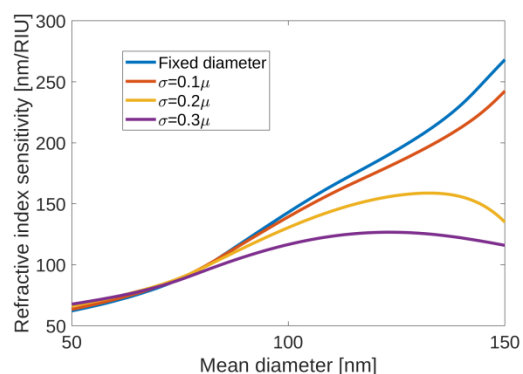


Fig. 1. Bulk refractive index sensitivity of gold spheres with normal distribution. (Assuming several different proportionality factors between the mean and the standard deviation of the particle size.)

The effects of both normal and log-normal size distributions were investigated.

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