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Longitudinal Localized Surface Plasmons in Trimer Nanocylinder System

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Abstract We report the near field localized surface plasmon characteristics of triangular system of silver nanocylinders and shell nanocylinders interacting with incident plane wave, studied using finite element method. The trimer nanocylinder system possesses far greater structural tunability than either a single nanorod or a nanoshell, along with much larger local field intensity enhancements and far greater sensitivity. The effect of geometrical as well as material parameters on the longitudinal localized plasmon resonance of the trimer nanosystem was investigated. The results provide insight in to the possible tunability of the localized plasmon modes which could find application in designing of chemical and biological sensors, electron emitters, etc.

Keywords Localized surface plasmon · Tunability · Trimer nanocylinders

Introduction

The localized plasmon resonance characteristics of various nanosystems have been investigated recently in order to design novel nanoscale optical devices for sensing, waveguiding, sub-wavelength imaging, color filtering, electron emission, spectral imaging, etc. [9, 14, 17, 22, 27, 29, 32]. Nanocylinders are considered to be simple structures for device fabrication as preparation of former is comparatively elementary [1]. Recently, various types of arrays of metal nanorods were produced using self-assembly of nanoparticles, lithographic, and nanoimprinting techniques [6, 31]. Nanocylinder shells can be constructed by forming a dielectric core inside metallic nanocylinders. In recent years, the physical and chemical properties of metallic nanoshells have received special attention because they possess several attractive features like tunability, hybridized plasmon modes, etc. making them interesting as nanoscale optical components [4, 25, 28]. Shell nanocylinders possess a plasmon-derived tunable optical resonance controlled by the dimensions of a core in a nanocylinder and the thickness of a metallic shell and span much of the visible and infrared regions of the optical spectrum [10, 21, 26]. Additionally, shell nanocylinders have been shown to enhance local electromagnetic fields in certain regions near their surfaces at specific wavelengths of light, controlled by nanostructure geometry thereby manipulating light in sub wavelength scale [2, 3, 30].

Recently, Weihai et. al. studied the extinction characteristics of gold nanorods [19]. Chen et. al. studied the sensing capability of nanorods utilizing the longitudinal plasmon mode [5]. Hobbs et. al. investigated electron emission from nanorod using the geometry-dependent longitudinal surface-plasmon resonance modes in the near-infrared [7, 8]. The transverse localized plasmon properties of nanocylinders were investigated elsewhere [11, 12]. In this letter, we report the effect of various geometrical and material parameters on the longitudinal localized surface plasmon resonance of a trimer nanocylinder system as well as shell nanocylinder system using finite element method. In the next section, we summarize the simulation method used to study the optical response of the system. The results of simulations are discussed in third section.

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