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Optical Properties of Plasmonic Nanopillars at Visible Wavelengths

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ABSTRACT—In the present article, we study the optical properties of conical plasmonic nanopillars at visible wavelengths. Interestingly, it is shown that two peaks in the optical extinction spectra can be observed for nanopillars with smaller lengths and corner angles. However, by increasing corner angle to 90^0, two distinct peaks shift, merge together and only a single broad peak is seen in the spectral range. In this special case, the conical nanopillars form the cylindrical nanorods, for which the quasistatic analytical solution of spheroid is used to compare the results.

KEYWORDS: Optical properties, Plasmonics, Localized surface plasmon, Conical Nanopillar.

I. INTRODUCTION

The fascinating interaction between light and noble metals in sizes smaller than the wavelength have found many promising applications in areas such as surface enhanced Raman spectroscopy (SERS) [1]-[2], chemical and biological sensing [3]-[4], negative index materials [5], nonlinear optics [6], and waveguiding [7].

The localized surface plasmon resonances (LSPRs) are responsible for these interesting optical properties in metal nanoparticles [8]. LSPR is non-propagating collective oscillation of the conduction electrons of metals in response to the applied electric field. The energy and intensity of the LSPR is highly sensitive to the shape and size of the nanoparticles and dielectric property of the surrounding media [9]. Therefore investigation the scattering properties of nanoparticles is one of the main challenges which researchers are facing in this field.

It is well known that the electromagnetic properties of a sphere can be formulated and determined using Mie theory based on the spherical harmonics [10]. Moreover, there is analytical solution for spheroid [10].

Recently, however, because of noticeable progresses in nanofabrication techniques such as lithographic methods [11], e-beam lithography [12], and other methods, which produce well defined shape and size, the existence of theories that can describe the optical properties of different nonspherical particles is useful.

Lack of analytical solutions to the Maxwell's equations in scattering problems for an arbitrary shape, make it necessary to use numerical methods such as FDTD, DDA, FEM, and etc. [13-15].

Investigation of gold (Au) nanopillars is interesting because of their broad band optical absorption efficiency [16]. Grigorenko et al. showed that with a set metallic nanodisks with different size, considerable enhancement of electromagnetic fields is achievable [17].