Interaction of Focused Light with a Prolate Spheroidal Nanoparticle near a Metallic Layer

K. Sendur, A. Sahinoz

Sabanci University, 34956, Istanbul, Turkey

The interaction of photons with metallic nanoparticles is important to a number of emerging nanotechnology applications due to the ability to obtain large enhancement and tight localization of electromagnetic fields in the vicinity of nanoparticles. Recently, there has been increasing interest in understanding the interaction of a focused beam of light with a nanoparticle. Numerical techniques based on finite difference time-domain [1] and finite element method [2], as well as analytical techniques based on generalized Mie theory have been used [2-4] to analyze the interaction of a focused beam with a nanoparticle. These studies [1-4] employ only spherical particles to study the interaction of a focused beam and nanoparticles. The interaction of a radially focused beam with elongated particles, such as a prolate spheroidal nanoparticle, is particularly interesting because it has the potential to produce even stronger near-field electromagnetic radiation.

In this study, near field radiation from a prolate spheriodal nanoparticle is investigated when it is illuminated with a radially polarized focused beam of light. Near-field radiation from the nanoparticle is investigated in the absence and presence of metallic layers. Figure 1 (a) illustrates the electric field intensity as a function of distance from the tip of the object with and without the metallic layer. Results suggest that the intensity improves in the presence of a metallic layer. The interaction of a radially polarized focused beam with a prolate spheroidal nanoparticle is enhanced by creating images of monopole charges using metallic layers. In addition, it is also observed that the presence of a metallic layer shifts the resonance of prolate spheroid toward longer wavelengths as shown in Fig. 1 (b).

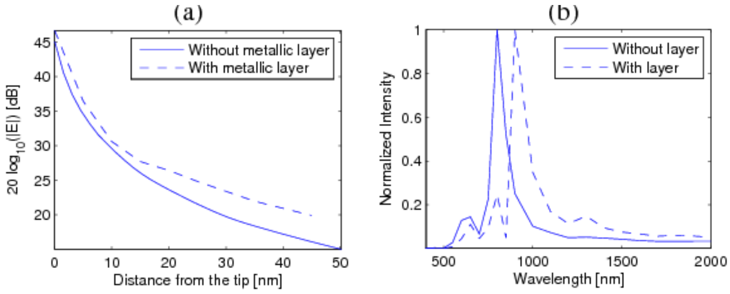

Fig. 1 (a) Intensity as a function of distance from the tip of the object with and without the metallic layer, and (b) frequency response of a prolate spheroid nanoparticle in the absence and presence of the metallic layer.

Figure 2 (a)-(c) illustrates the dipole, quadruple, and off resonance field distributions for a prolate spheroidal particles when it is illuminated with a radially focused beam of light. At dipole resonance, the intensity at the tips of the nanoparticle shows large intensity enhancement compared to off resonance. A comparison of the dipolar and quadruple distributions for larger particles suggests that the field distributions at quadruple resonance have strong lobes on the perpendicular axis.

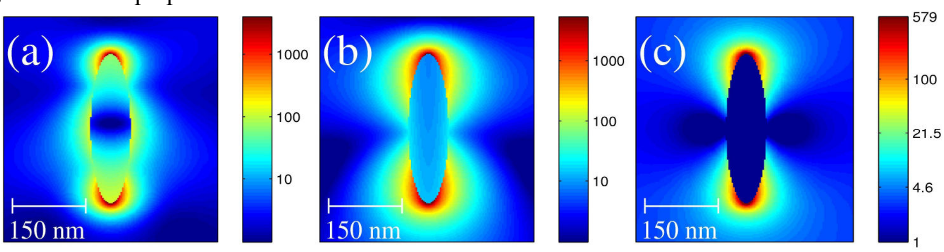

Fig. 2 Electric field intensity distribution in the vicinity of a gold prolate spheroidal nanoparticle: (a) at the quadruple resonance wavelength, (b) at the dipole resonance wavelength, and (c) at the off resonance wavelength.

References

[1] W. A. Challener, I. K. Sendur, and C. Peng, "Scattered field formulation of finite difference time domain for a focused light beam in a dense media with lossy materials," Opt. Express **11**, 3160–3170 (2003).

[2] K. Sendur, W. Challener, and O. Mryasov, "Interaction of spherical nanoparticles with a highly focused beam of light," Opt. Express **16**, 2874–2886 (2008).

[3] Lerm, G. Bachelier, P. Billaud, C. Bonnet, M. Broyer, E. Cottancin, S. Marhaba, and M. Pellarin, "Optical response of a single spherical particle in a tightly focused light beam : application to the spatial modulation spectroscopy technique," J. Opt. Soc. Am. A **25**, 493 (2008).

[4] N. M. Mojarad, V. Sandoghdar, and M. Agio, "Plasmon spectra of nanospheres under a tightly focused beam," J. Opt. Soc. Am. B **25**, 651-658 (2008).

978-1-4244-4080-1/09/$25.00