FDTD simulation on plasmon in gold nanorod excited by scanning near field optical microscopy

K. Sawada, H. Nakamura[a], Y. Tamura[b], K. Imura[c], and H. Okamoto[d]

Shinshu University, 4-17-1, Wakasato, Nagano 380-8553, Japan
[a] National Institute for Fusion Science,322-6 Oroshi-cho, Toki 509-5292, Japan
[b] Konan University, 8-9-1 Okamoto, Higashinada-ku, Kobe 658-8501, Japan
[c] Waseda University, 3-4-1 Okubo, Shinjyuku, Tokyo 169-8555, Japan
[d] Institute for Molecular Science, 38 Myodaiji, Okazaki 444-8585, Japan

ksawada@gipwc.shinshu-u.ac.jp

The quasi-free electrons of metals behave like a plasma. The longitudinal electromagnetic charge density waves in metals are referred as plasmon. The study of optical phenomena related to the electromagnetic response of metals is rapidly growing field, which is mostly concerned with the control of optical radiation on the subwavelength scale.

Imura *et al*. have investigated optical properties of gold nanorod using appertured-type scanning near-field optical microscope (SNOM) [1]. Transmission images observed show oscillating pattern along the long axis of the nanorod. These spatial characteristics were explained by the calculated local density-of-states maps (LDOS). However, the electromagnetic interaction between the nanorod and the surface of the tip of the SNOM was not considered in the LDOS discussion. In this study, in order to include the effect, we have constructed a code which is based on the Finite-Difference Time-Domain (FDTD) method. The dispersion of the gold of the nanorod and the surface of the tip of the SNOM is modeled according to the Drude-Lorentz model which gives accurate description for the dispersion of the gold in the range of wavelengths between 500 nm and 1000 nm [2].

First, we investigated the excitation of surface plasmon with a dipole source placed 2 nm above a gold nanorod on a glass substrate by the FDTD code. The length and the diameter of the nanorod were 500 nm and 20 nm, respectively. The wavelength of incident light was 700nm and the dipole moment was parallel to the long axis of the nanorod. The distribution of the intensity of the electric field reproduced a pattern of the LDOS. Figure 1 shows a snapshot of the electric field.

Next, the dipole source was replaced as the excitation source by the SNOM in order to simulate the experiment of Ref.1. The transmission images of the nanorod by scanning of the SNOM were investigated. Figure 2 shows the intensity of the electric field.

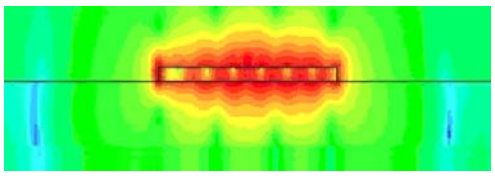

Figure 1. Excitation of plasmon in gold nanorod by the dipole source.

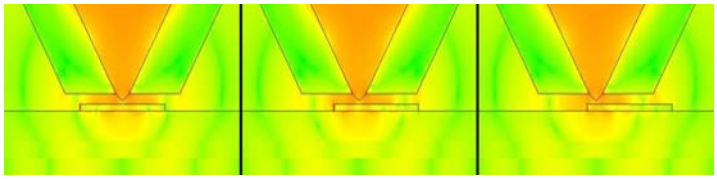

Figure 2. Excitation of plasmon in gold nanorod by the SNOM.

[1] K. Imura, T. Nagahara, H. Okamoto, J. Chem. Phys. **122** (2005) 154701.
[2] Alexandre Vial, Anne-Sophie Grimault, Demetrio Macias, Dominique Barchiesi, and Marc Lamy de la Chapelle, Phys. Rev. B **71** (2005) 085416.