Type of presentation: Poster

IT-1-P-2346 Effects of dielectric substrate on localized surface plasmon in a silver nano-particle

Fujiyoshi Y.[1], Nemoto T.[1], Kurata H.[1]

[1]Institute for Chemical Research, Kyoto University, Kyoto, Japan

Email of the presenting author: fujiyoshi@eels.kuicr.kyoto-u.ac.jp

Recently localized surface plasmons (LSPs) which are collective oscillation of conduction electrons of metallic nano-particles (NPs) attract researchers in nano-optics because of strong optical confinement and electric field enhancement, leading to many applications including biochemical sensors and surface-enhanced Raman spectroscopy (SERS) etc. Since the dielectric environment around the NP affects the property of LSPs, it is important to elucidate the effects of dielectric materials supporting NPs on LSPs.

In the present work, we examined special distributions of LSP excited on a silver NP supported by MgO substrate using electron energy loss spectroscopy (EELS) combined with scanning transmission electron microscopy (STEM). Spectral imaging (SI) data were acquired along the direction parallel to the MgO surface supporting a silver NP, which enabled us to observe the intensity distribution of LSP excitation as a function of the distance from the silver NP/MgO interface. The experiment was performed by an aberration corrected STEM (JEM-9980TKP1) equipped with a cold-FEG.

Figure 1 and 2 show a HAADF image of silver NP on MgO substrate and its LSP map extracted from SI data, respectively. From the HAADF image the NP can be regarded as a sphere. When a spherical metal particle is isolated in vacuum, the excitation probability of LSP should distribute isotropically around the particle. However, the LSP map in Fig. 2 shows anisotropic distribution, that is, the intensity at the top surface of silver NP is strong compared to that at other positions, which means that the effect of dielectric substrate is remarkable. In order to interpret such anisotropic distribution, we simulated the electromagnetic field induced in the silver NP on MgO substrate using finite-difference time-domain (FDTD) method.

Figure 3 shows the spatial distribution of field calculated by assuming the incident plane waves polarized perpendicular (a) and parallel (b) to the substrate surface. When the polarization of incident wave is perpendicular to the substrate, the field strength in the NP on MgO is enhanced compared to that in the isolated NP as shown in Fig. 3(a), which corresponds to the observed strong excitation at position A in Fig. 2. In case of the parallel polarization the field strength in the NP on MgO is weakened (Fig. 3(b)), corresponding to the observed intensity at position B in Fig. 2. Therefore, the anisotropic distribution of the LSP excitation in silver NP on MgO surface can be attributed to the direction of electric polarization induced in the NP depending on the electron positions.

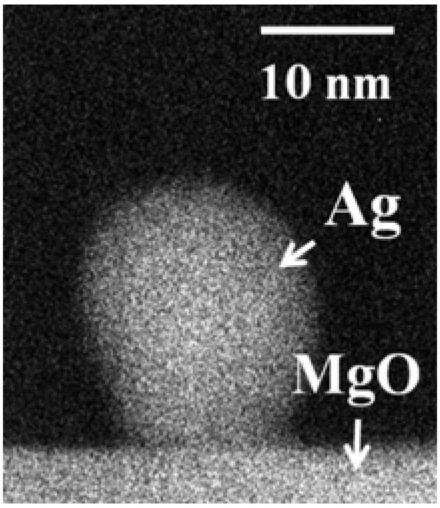

Fig. 1: HAADF image of a silver NP supported on MgO surface.

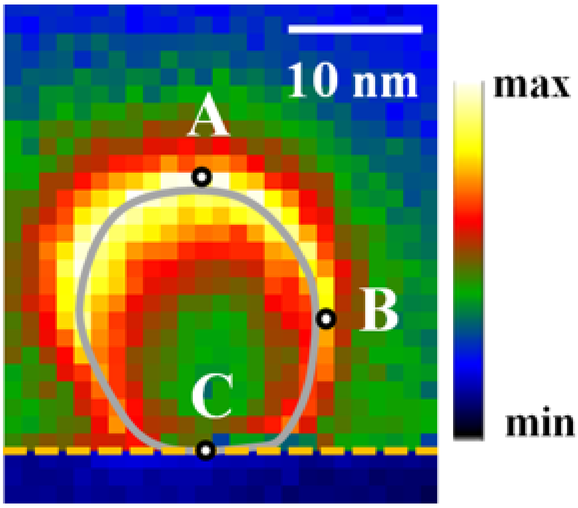

Fig. 2: LSP map extracted from the energy range from 3.2 to 3.6 eV in the SI data.

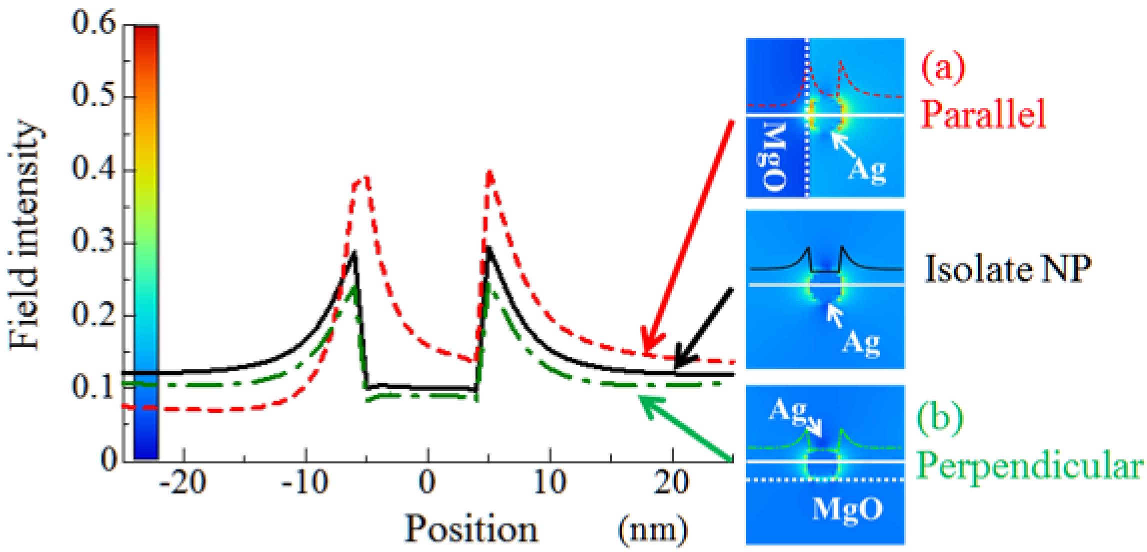

Fig. 3: Spatial distribution of electromagnetic field calculated by FDTD simulations. Incident plane waves were assumed to be polarized parallel (a) and perpendicular (b) to the substrate surface. Solid and broken lines correspond to the intensity profiles for an isolated silver NP and the silver NP supported on MgO surface, respectively.