Study of Surface Plasmon Resonances on Assemblies of Slits in Thin Ag Films by Low-Loss EFTEM Imaging

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With the ongoing developments in nanotechnology, surface plasmon resonances (SPRs) have started to play a crucial role in many different areas of science. Surface Plasmon resonances are described as collective oscillations in the valence electron density at the surface of a conductor. They have especially received attention in the areas of biosensing in cancer diagnostics [1], near-field Raman spectroscopy [2] and different applications in optoelectronics.

In this study, the optical response of a specially perforated thin Ag film is investigated with EFTEM. The experiments were carried out in the 200 kV FEG-TEM Sub-Electron-Volt-Sub-Ångstrom-Microscope (Zeiss SESAM) equipped with an electrostatic monochromator and the in-column MANDOLINE filter [3]. The superior properties of this instrument enable EFTEM imaging in the ultraviolet–near-infrared domain with very high energy resolution and spatial sampling [4].

The Ag specimen was prepared as follows: Using physical vapour deposition, a Ag film with about 100 nm thickness was deposited onto a C film on a standard TEM Cu grid (the dimensions of each mesh is 100 × 100 μm^2). Focused ion beam (FIB) technique was used to drill different slit structures into the Ag film. The EFTEM series were acquired in the energy loss range from 0.4 eV to 5 eV by using a 0.19 eV energy slit and a step size of 0.2 eV. The EFTEM images were recorded on a 2k × 2k CCD camera with 8 times binning and an acquisition time of 30 sec / image (at each energy loss 3 images were recorded with an exposure time of 10 s and then aligned and averaged).

Figure 1(a) shows a zero loss bright-field image of a double-slit structure with dimensions of 200 nm × 1 μm and a separation of 100 nm. A sample image taken from the drift-corrected EFTEM series at an energy loss of 0.6 eV is shown in figure 1(b). The intensity distribution is attributed to a localized plasmon resonance. Such resonances will be discussed and compared with numerical simulations [5].

1. I.H. El-Sayed et al., Nano Letters **5**(5) (2005), p.829-834.
2. J. Grand et al., Synthetic Metals **139** (2003), p.621-624.
3. C.T. Koch et al., Microscopy and Microanalysis **12** (2006), p.506.
4. C.T. Koch et al., 14th European Microscopy Congress edited by M. Luysberg, K. Tillmann and T. Weirich, EMC **Vol.1** (2008), p.447.
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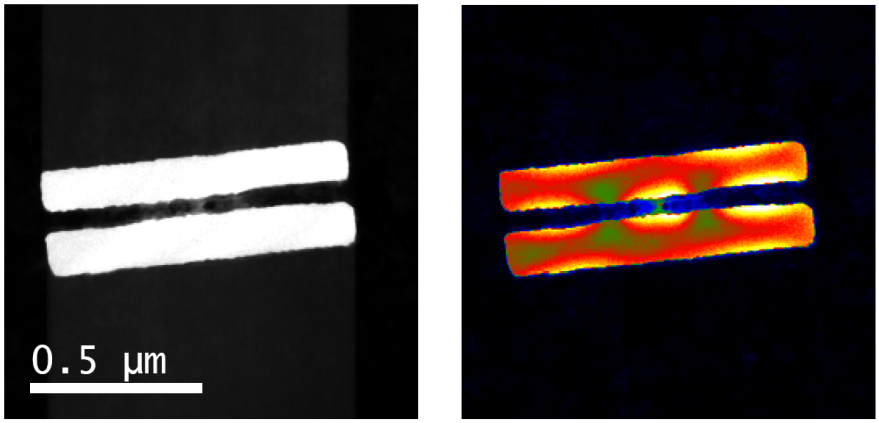

(a) (b)

Figure 1. (a) Bright-field image of two rectangular slits with nominal dimensions of 200 nm × 1 µm with a separation of 100 nm. (b) Energy-filtered image at an energy loss of 0.6 eV, acquired with an energy slit width of 0.19 eV, and a monochromator slit of 0.2 eV. The scale bar is the same for both images.

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