Surface plasmon resonance effects in a perforated Ag film studied by energy-filtering TEM

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The visualization of localized surface plasmon resonances (LSPR) on the nanometer scale in combination with spectral information over the entire visible range is of prime importance in the field of biosensors, surface-enhanced Raman spectroscopy (SERS), aperture-less scanning near-field optical microscopy (SNOM), and for the design of metamaterials. But also the understanding of the abnormal transmission of light through sub-wavelength holes may gain by this technique.

With the advent of monochromators and highly dispersive energy filters, energy-filtering TEM has now become available for the study of the optical response of materials. This technique was applied to the detection of band gaps [1] as well as to the study of surface plasmons on metal particles, like Ag nanoprisms [2–4] or Au nanorods [5].

Here, the dielectric response of holes in a 100 nm thick Ag film, drilled by using a focused ion beam, is studied by acquiring EFTEM series in the energy range between 0.4 and 4 eV using the Zeiss SESAM microscope (Fig.1). The energy-slit width was 0.2 eV. Apart from multipolar ring-shaped resonances, visible particularly at the isolated holes in the upper row, a number of LSPRs are found which are due to the strong coupling effects between adjacent holes. They sensitively depend on the hole arrangement [6].

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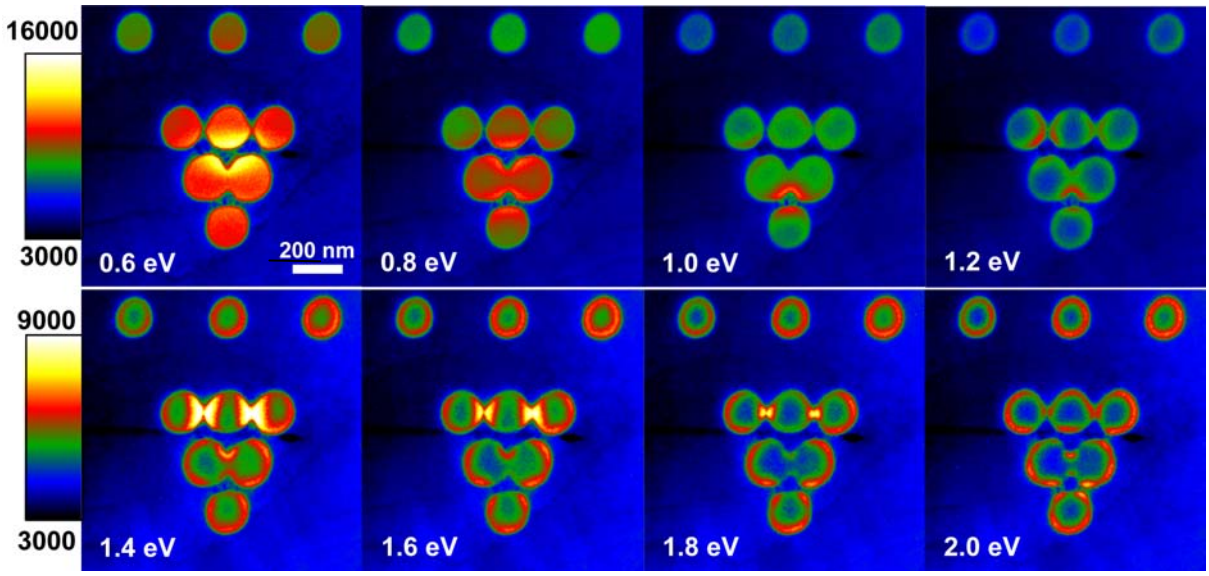

Figure 1. Series of energy-filtered images of a hole arrangement in a thin Ag foil. A number of localized plasmon resonances can be identified. The images are displayed in false-color (increasing intensity: blue-green-red-yellow).

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