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MS-1-P-3419 Characteristaion of local surface plasmon resonance modes of metallic nanostructures with cathodoluminescence and electron energy loss spectroscopy in the (S)TEM

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There is significant interest in understanding and controlling surface plasmon resonance modes of metallic nanostructures for use in chemical sensing and nano-optics applications. The optical effects of local surface plasmon resonance (LSPR) modes are only observable at a length scale below the diffraction limit of far field optical experiments meaning that alternative techniques are needed to study individual nanostructures. A focussed electron beam of a (scanning) transmission electron microscope (S)TEM can be used to generate local surface plasmon resonance (LSPR) modes; cathodoluminescence (CL) and electron energy loss spectroscopy techniques can be used to observe the generation and propagation of LSPRs with high spatial (<1nm) and spectral resolution (<2meV) and allow direct correlation with particle morphology. Here we report the use of CL and EELS in the characterisation of gold and silver nanoparticles using the Gatan Vulcan CL detector and Gatan GIF Quantum EEL spectrometer.
Figure 1 shows luminescence patterns of gold prisms acquired by (S)TEM-CL. Gold prisms of different size reveal very different LSPR patterns; a gold prism with sides of 250nm shows strong emission at 1.80eV (660nm) at the three corners (Figure 3c) whereas an 800nm particle shows luminescence dominated by a strong central LSPR node (1.53eV, 803nm) with other lower intensity LSPR modes along the edges (1.43 and 1.70eV, 870 and 705nm).
Light emitted from the specimen in the forward and backwards directions (in the direction of, and in the opposite direction to the fast electron) was measured (simultaneously) enabling differences in the intensity and spectral characteristics to be determined. A simple model system of a 120nm diameter sliver nanosphere was investigated. Preferential emission of the quadrapole LSPR mode was observed in the forward scattered direction whereas the dipole LSPR mode was preferentially emitted in the backward scattered direction, in agreement with Mie theory.

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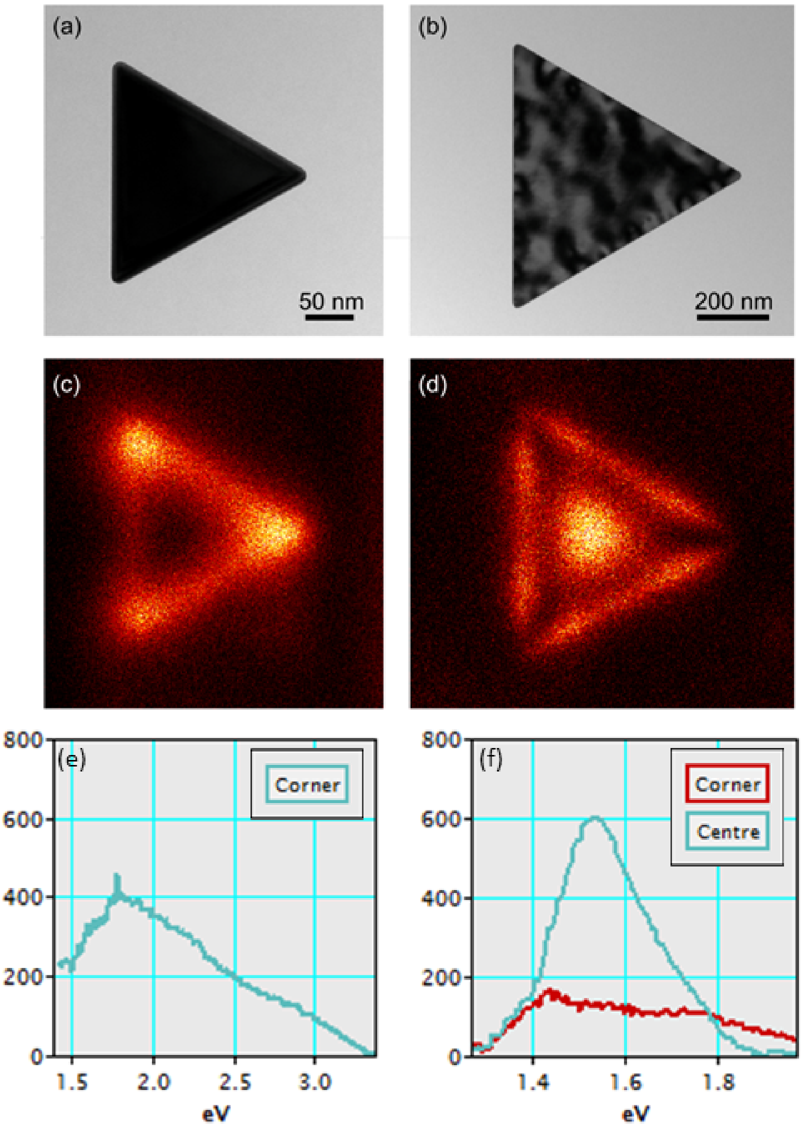

Fig. 1: Figure 1. (a) and (b) bright field STEM image of a two gold prisms (250 and 800nm sides respectively); (c) and (d) panchromatic STEM-CL images reveal ‘bright’ local surface plasmon resonance modes (e) and (f) CL spectra acquired from selected positions.