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STEM/EELS Studies of Nanoparticles

C. Mitterbauer,* A.L. Pickering,** S.M. Kauzlarich,** P.P. Power,** and N.D. Browning*,***

*Chemical Engineering and Materials Science, University of California, 1 Shields Avenue, Davis, California, 95616, USA
**Department of Chemistry, University of California, 1 Shields Avenue, Davis, CA, 95616, USA
***Chemistry and Materials Science, Lawrence Livermore National Laboratory, Livermore, CA, 94550, USA

Scanning transmission electron microscopy (STEM) in combination with electron energy loss spectroscopy (EELS) provides the ideal tool for imaging and analyzing different kinds of nanoparticles with atomic resolution. Using the so-called 'Z-contrast technique' in the STEM, the contrast in the image has atomic number (Z) sensitivity and the experimental conditions for Z-contrast imaging are the same as for EELS, which makes it possible to perform both experiments simultaneously with the same atomic resolution [1]. The STEM results were obtained using a JEOL JEM-2500SE STEM/TEM, equipped with a Schottky field-emission source operated at 200 kV and a post column Gatan imaging filter (863 GIF Tridiem) for EELS.

In this paper we present the results of two of our recent studies of nanoparticles. All specimens were prepared by dropping 0.05 ml of solution onto a copper mesh coated with a holey carbon film, and the solvent was evaporated prior to STEM analysis. Figure 1A shows a STEM dark field image of an octaoxy-capped (-$O(CH_2)_7CH_3$) amorphous boron nanoparticle, with a diameter of around 20 nm [2]. The low loss spectra in Figure 1B trace the increased plasmon excitation on the particle (points 3-6). The core loss spectra (Fig. 1C) were background subtracted using a power low fit [3] and normalized to the maximum of the carbon K edge. As expected, the intensities of both boron K and oxygen K edge are proportionately increased as the beam was placed on the nanoparticle. This means that the composition is homogenous and proofs the existence of Boron nanoparticles.

The second example (Fig. 2A) shows the bright field image of a gold particle on a holey carbon grid. The particle shown has a diameter of around 4 nm. Figure 2B presents the change in the low loss region. Figure 2C illustrates the obvious change in the carbon K intensity between the carbon foil (points 1, 2 and 5), the particle (points 3 and 4) and the vacuum (point 6).

In conclusion STEM/EELS analysis has been used to determine the size and composition of boron and gold nanoparticles. Our investigations comprise a variety of nanoparticles and the application of in-situ and tomographic techniques in our STEM to a fundamental understanding of nanoparticles [4].

References
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[4] We kindly acknowledge financial support for C. Mitterbauer by the U.S. Department of Energy Grant, # DE-FG02-03ER46057, and the National Science Foundation, Grant # CTS-0321356.

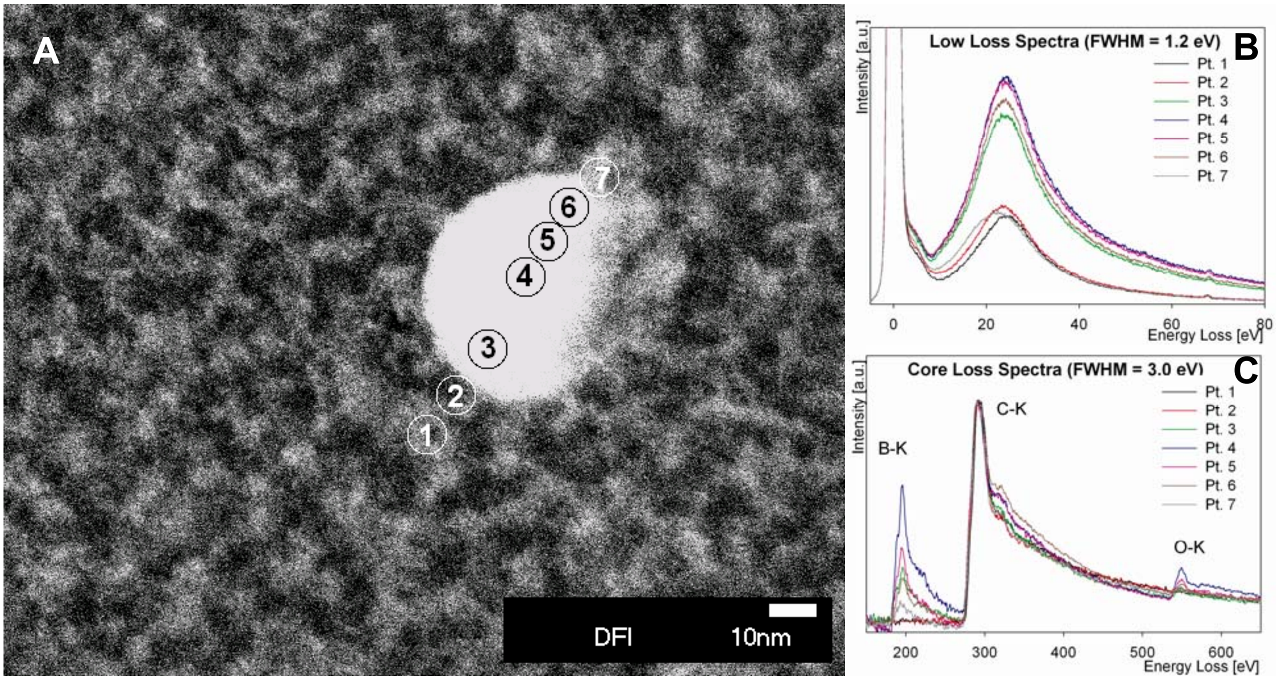

Fig. 1: (A) STEM dark field image of an octaoxy-capped amorphous boron nanoparticle on a holey carbon film. (B) The low loss spectra are normalized to the height of the ZLP. (C) The core loss spectra are background subtracted and normalized to the maximum of the carbon K edge.

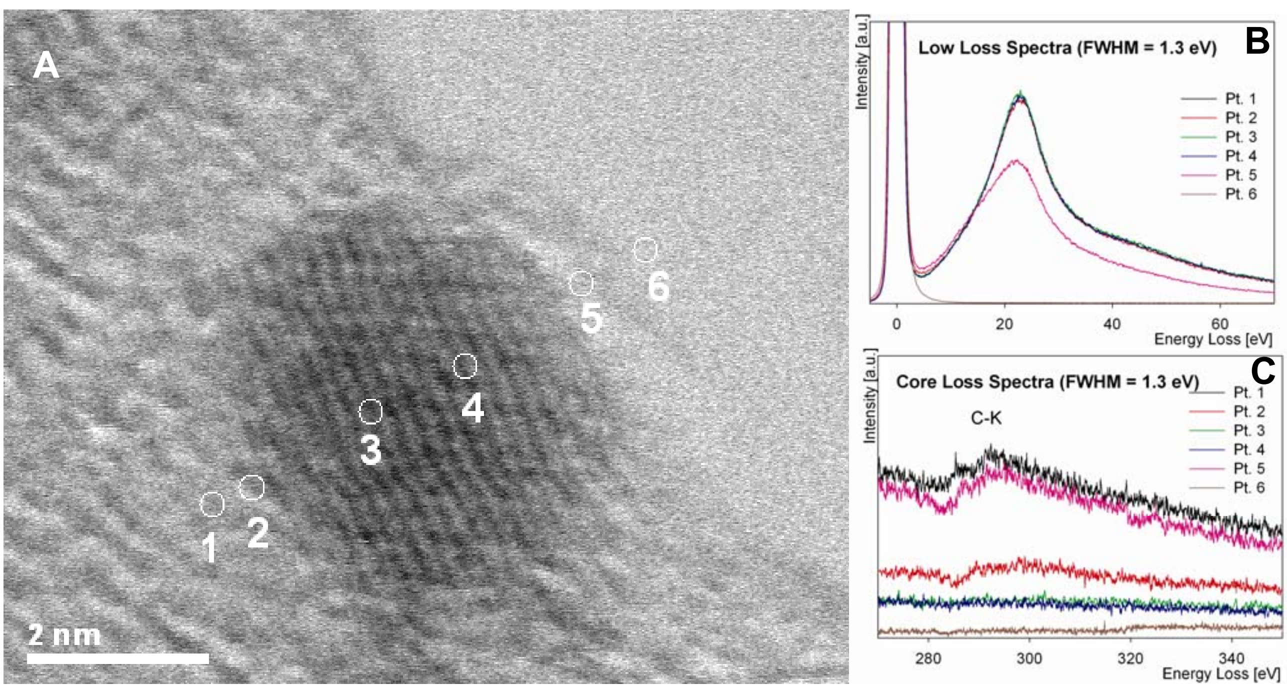

Fig. 2: (A) STEM bright field image of a gold nanoparticle on a holey carbon film. (B) The low loss spectra are normalized to the height of the ZLP. (C) Carbon K edge spectra. In order to show the difference between the supporting foil and the gold nanoparticles, the background is not subtracted.

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