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TEM Analysis of EuS/CdSe Nano Heterostructures

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Inorganic nanoparticles exhibit a wide range of size, composition and shape dependent properties. Unlike their bulk counterparts, the size-dependent properties of nanoparticles may be tailored to suit a particular application. The union of two or more suitable elements into a multi-component heterostructure offers access to an even greater range of materials properties based on the specific properties characteristic to each domain. Such heterostructures are attractive candidates for semiconductor applications, where the band gap of a nanoparticle may be tuned with a suitable choice of domain components.

EuS/CdSe composite nanostructures, synthesised by the selective growth of spherical EuS nanocrystals on the tips of CdSe nanorods, are particularly interesting. Bulk EuS is a ferromagnetic semiconductor with a band gap of 1.6 eV [1-3]. The 4f−5d electronic transition and spin configuration of EuS leads to unique optical and magnetic properties [4], making nanocrystalline EuS a candidate for optomagnetic and luminescent materials [5,6]. The optical properties of collective EuS and CdSe nanoparticles have been investigated previously [7], however the study of individual EuS/CdSe heterostructures with a high resolution TEM are necessary to understand the relationship between the structure and optical properties of composite nanoparticles. Experiments were carried out with an aberration corrected transmission electron microscope FEI Titan 80-300 equipped with an aberration corrector, a monochromator and a high resolution electron energy loss spectrometer. High resolution images of the heterostructures reveal the nature of the single crystal CdSe domain and shape of the capping EuS sphere (Fig. 1A). EFTEM images clearly delineate the CdSe and EuS domains within the heterostructures, the latter appearing brighter due to predominant scattering at high angles from the heavy Eu nucleus (Fig. 1C, D). An EFTEM data cube was acquired over a 100-200 eV energy loss window. Core losses in Eu are spatially resolved in individual nanoparticles of approximately 10nm in length (Fig.1B, C). The integrated EuS core loss spectrum extracted from the EuS domain of a single nanoparticle features two peaks in agreement with energy loss spectrum from bulk EuS (Fig. 1E) [8]. Further work is in progress to obtain low energy loss EELS data from individual nanoparticles in order to obtain information on the optical properties of particles of varying size and shape. The plasmon energies will be studied as a function of particle morphology and local environment.

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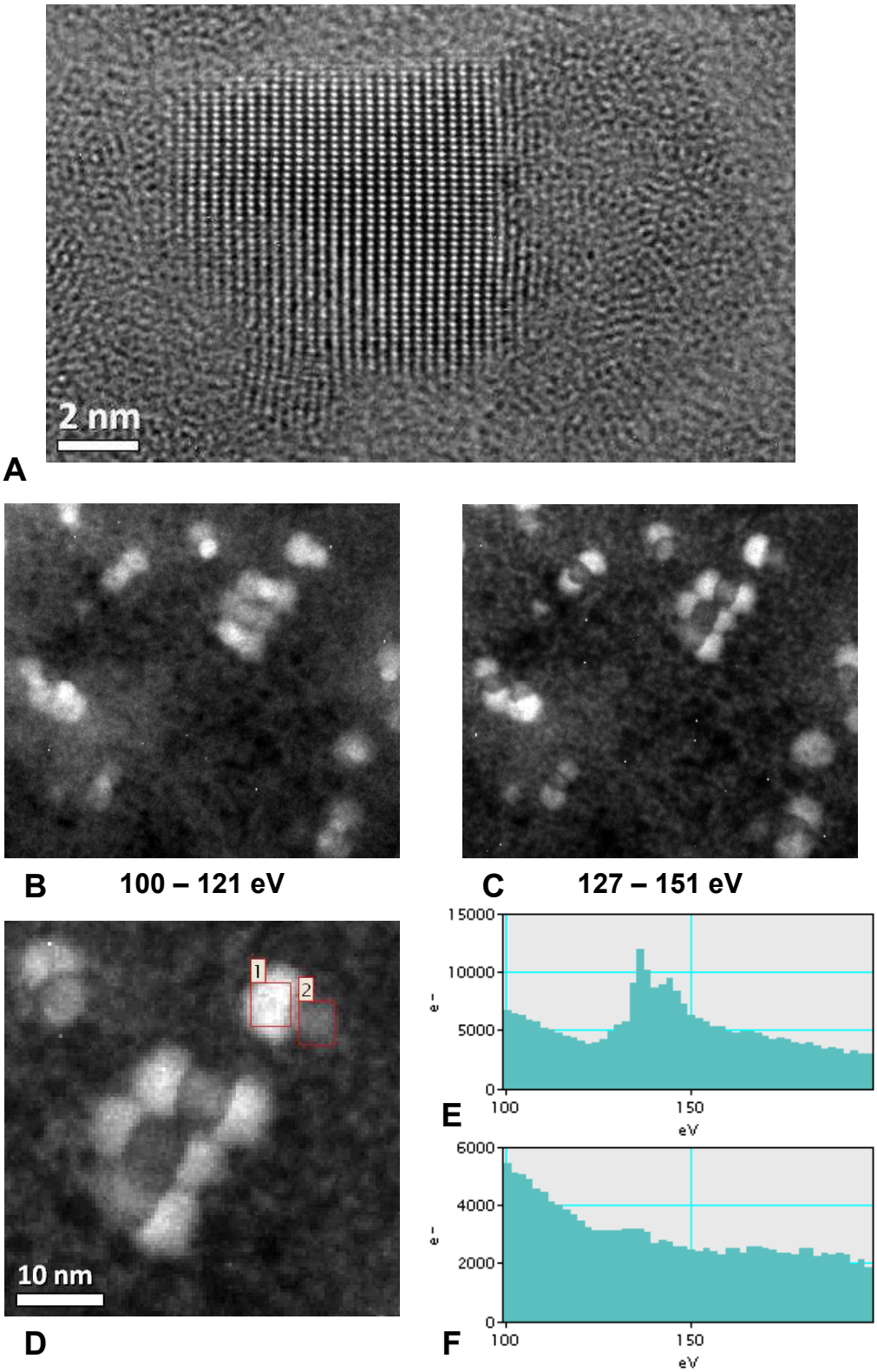

FIG. 1. A HRTEM image (A) and EFTEM images (B,C,D) of EuS/CdSe heterostructures. EFTEM images were integrated over energy windows prior to (100-121eV) (B) and including the Eu core loss region (127-151eV) (C). An EELS spectrum may be extracted (D) from the EuS (E) and CdSe (F) domain of an individual nanoparticle.

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