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Low Voltage Electron Microscopy Applied to Core Shell CdSe/CdZnS QDs

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Functionalized QDs are of emerging interest nowadays in the broad field of ultrastable contrast agents for bioimaging applications [1]. Irradiation damage and diminishing contrast are the major problems for conventional TEM investigations. Low energy electrons show significant different scattering behaviour compared to commonly used faster electrons with an energy between 80keV and 300keV as: (1) the inelastic (as well as the elastic) scattering cross section increases, and therefore an significant increase in image contrast of EFTEM (as well as TEM) images can be expected; (2) the elastic (electron-nucleus) damage mechanisms decrease significantly and the inelastic (electron-electron) damage mechanisms increase. Here we report the 20kV EFTEM investigation of core shell CdSe/CdZnS QDs with an albumin polymere surface coating [2] on single-layer graphene, the thinnest substrate possible. The investigations were performed with the monochromized and imaging aberration-corrected SALVE1 microscope [2] operating at 20 kV equipped with an corrected incolumn Omega energy filter and a 4kx4k CMOS Tietz camera (F416) with an energy slit width of 1.1 eV, an energy resolution of 0.18 eV (FWHM of ZLP). A series of energy filtered images was taken up to an energy loss of 40 eV with an energy delta of 0.5 eV between each image and an illumination time of 5s per image. This datacube was used to obtain EEL spectra by selecting specific sample positions and integrating over 20x20 pixel. The extacted spectra reveal significant changes in the peak shape and position for the different sample positions like single and double layered graphene, the protein and the core and shell of the QDs. One leftover question is now the influence of electron irradiation on the light efficiency of the QDs. Therfore dose rate and accelerating voltage depend studies in the SEM were started. [1] Liu, Y.; Solomon, M.; Achilefu, S. Med Res Rev. 2010, 31. [2] U.Kaiser et al Ultramicroscopy 111 (2011) 1239 [3] This work was supported by the DFG (German Research Foundation) and the Ministry of Science, Research and the Arts (MWK) of Baden-Wurttemberg in the frame of the SALVE (Sub Angstrom Low-Voltage Electron microscopy and spectroscopy project.