YY2.07

Chromatic Aberration-corrected Energy-filtered Transmission Electron Microscopy on the Atomic Scale

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Chromatic aberration correction in the transmission electron microscope (TEM) allows large energy windows and large objective aperture sizes to be used without compromising the spatial resolution of energy-loss images. Background-subtracted chemical maps can then be recorded on the atomic scale with a signal-to-noise ratio that is suitable for quantitative high-resolution energy-filtered TEM (EFTEM), even at accelerating voltages of 80 kV or below. We have acquired preliminary experimental atomic-scale EFTEM images of perovskite oxides and thin layered materials such as BN and MoS2 at accelerating voltages of 80 - 300 kV using the chromatic and spherical aberration-corrected ‘PICO' TEM installed in Juelich. Our experimental results show that, in order to obtain reliable atomic-scale EFTEM images, a higher degree of aberration control and microscope stability is required compared to experiments with conventional, non energy-filtered HRTEM images. The strengthened requirements are essentially due to the preservation of elastic scattering and phase contrast in background and core-loss images in combination with acquisition times on the order of several seconds. Furthermore, the calculation of core-loss intensities necessitates alignment of the background and core-loss images to sub-Ångstrom accuracy. In confirmation of theoretical predictions, our results show that a knowledge of specimen thickness and defocus for a given accelerating voltage is important for the reliable interpretation of exit-plane intensities and therefore elemental distributions on the atomic scale.