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Energy-Filtered and Low-Voltage Chromatic Aberration-Corrected High-Resolution TEM on the PICO Instrument

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The advent of chromatic aberration-correction in the transmission electron microscope (TEM) offers new prospects for high-resolution imaging at low voltages and energy-selective imaging. Recent improvements in the setup of the achroplanatic CEOS CCOR corrector allow for sub-ångstrom resolution at an acceleration voltage of 50 kV and enhanced optical stability over the timespan of several minutes provides for reliable energy-filtered transmission electron microscopy (EFTEM) spectrum image data at atomic resolution. Experimental examples of low-voltage high-resolution and energy-filtered images of complex oxides, thin layered materials and nanoparticles obtained with Jülich's chromatic aberration corrected microscope "PICO" will be presented to demonstrate the unique optical properties of the CCOR.

Atomic-scale transmission electron microscopy pushed towards low electron energy by virtue of chromatic aberration correction opens a new horizon for direct imaging of atomic details of nanostructures at reduced radiation damage. Here it is used to analyse the structure and defects in atomic sheets of 2D materials and catalytic hybrid nanostructures.

EFTEM showing atomic detail becomes practicable because of the negligible chromatic focus spread after chromatic aberration correction. The achroplanatic CEOS CCOR corrector allows to record elemental maps on a large field of view with large energy windows, which is essential for the dose-efficient acquisition of atomic resolution images formed by the weak inelastic core-loss scattering. Aspects of atomic resolution EFTEM will be discussed. The quantification of EFTEM maps towards atomic resolution chemical composition maps is in general complicated by the preservation of elastic contrast emerging from elastic scattering. Thin specimen and careful choice of contrast transfer settings yield directly useful qualitative elemental maps on the atomic scale.