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Towards Quantitative Aberration-Corrected Monochromated Environmental High-Resolution Transmission Electron Microscopy of Dynamic Processes

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Modern environmental transmission electron microscopes (ETEMs) [1, 2] can be equipped with aberration correctors and monochromators to improve spatial resolution and spectral sensitivity during dynamic studies of chemical reactions and growth processes. We have recently installed an FEI Titan 80-300 ETEM with an objective lens aberration corrector, a monochromator and a differential pumping system. Seven different gases (H2, He, CH4, N2, CO, O2 and Ar) can be introduced into the microscope at pressures of up to ~1500 Pa. Additional gases can be connected when required. The combined capabilities of ETEM and aberration correction provide unique possibilities to study the surface structures of catalytic materials, which are highly dependent on the surrounding atmosphere. As a model system, we have chosen to study Au nanoparticles on BN in oxidizing and reducing environments at elevated temperature in the TEM, while maintaining lattice resolution of both the BN and the Au. Some of the particles are observed to sinter by migration and coalescence, while others decrease in size as their neighbors grow by Ostwald ripening. These observations provide evidence that several sintering mechanisms can occur simultaneously. In the future, in order to quantify image contrast in such experiments, a deeper understanding is required of the scattering of fast electrons in the presence of gas in the microscope, as well as the effect of ionization of the gas and the specimen on chemical reaction rates, even at room temperature [3, 4].

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