In situ HRTEM – Image corrected and monochromated Titan equipped with environmental cell

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High-resolution environmental TEM has become available within the last decade. This includes atomic resolution imaging of catalyst nanoparticles under controlled gas atmospheres up to 20mbar pressure [1,2,3] as well as dynamical growth studies of semiconductor nanowires and of carbon containing nanowires [4,5].

At the newly inaugurated Center for Electron Nanoscopy (CEN) at the Technical University of Denmark the next step for improved resolution in HRTEM under non-vacuum conditions has been taken. A monochromated Titan TEM with a spherical aberration (C_s) image corrector has been installed and equipped with an environmental cell. The microscope achieves a resolution of 1.1 Ångström with a controlled gas environment around the specimen. Besides the improved spatial resolution for environmental TEM the monochromated microscope is equipped with a post-column energy filter providing the opportunity for high energy resolution EELS of both gas phase and solid samples.

Accurate control of sample temperature, gas flow and gas composition is essential to prevent thermal drift in the specimen for stable long term experiments. A gas inlet system has been specially designed to allow maximum control over the gas mixing and flow into the microscope column.

Under optimum conditions it will be feasible to directly study phenomena such as surface (re)constructions of catalytic nanoparticles under working conditions, crystal twinning and grain boundaries. Operating in a dynamic mode, allows for the investigation of phenomena like diffusion and nanowire growth mechanisms.

Figure 1 demonstrates the easily achievable resolution of at least 1.1Å at 0.5mbar N_2 pressure by a Youngs fringe experiment. In Figure 2, images of an Au/Al_2O_3 based catalyst for methanol synthesis acquired in situ with working pressures up to 5mbar N_2 are shown. The {111} fringes of the Au particle are easily recognized and C_s correction means no delocalization.

First results from CEN's environmental C_s image corrected Titan will be presented.

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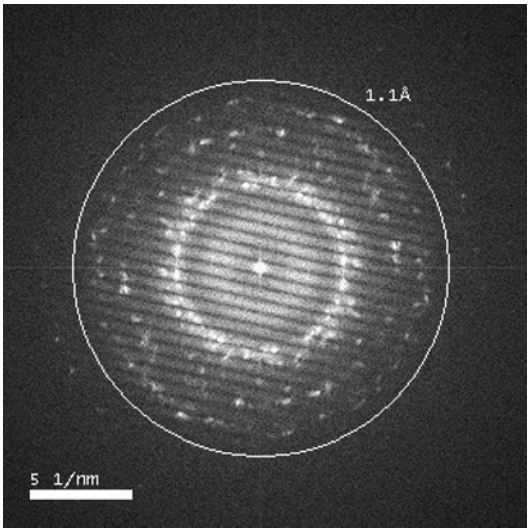

Figure 1. Youngs fringe experiment showing the resolution of the environmental Titan under 0.5mbar N_2 pressure. The fringes are easily recognized up to 9.2 nm^{-1} corresponding to 1.1 Å.

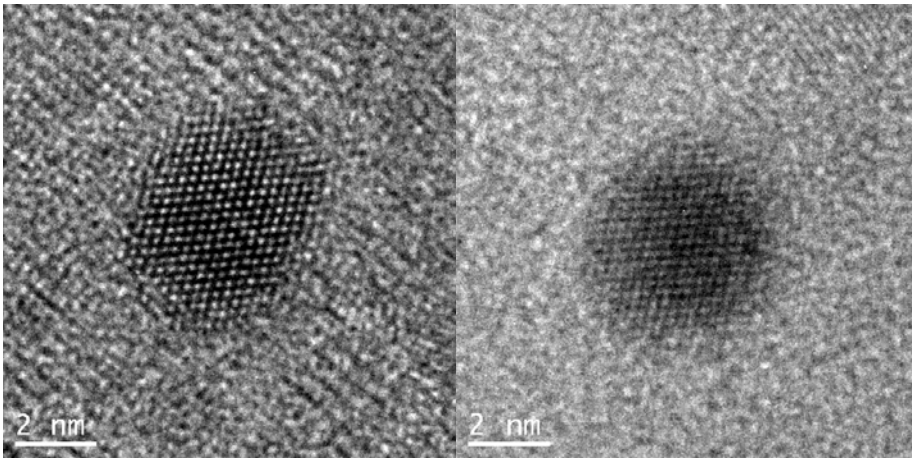

Figure 2. Image of Au particle supported on Al_2O_3 recorded at 0.5mbar (left) and 5mbar (right) pressure of N_2. The sample is a catalyst for methanol synthesis.