MS42-01 | High Energy Surface X-Ray Diffraction from Surfaces and Nanoparticles in Operando Catalysis

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Catalysts are complex material systems consisting of metal nanoparticles dispersed on highly branched oxide supports. They accelerate desired chemical reactions with applications ranging from exhaust gas treatment to chemical industry. To improve catalyst performance, an atomic-scale understanding of the catalyst structure and its correlation to the catalytic activity under realistic reaction conditions is inevitable.

In my presentation I will discuss how High-Energy Surface X-Ray Diffraction (HESXRD: photon energy E=70-80 keV) allows for studying under operando conditions the structure of different model catalyst systems, including epitaxial metal nanoparticles and single crystal surfaces. Hence, our CO oxidation study performed at beamline ID15 (ESRF) revealed the composition- and shape-dependent sintering of Al_2O_3(0001)-supported alloy nanoparticles of varying Pt-Rh composition: while the flat-shaped Pt-rich particles underwent tremendous sintering, the compact-shaped Rh-rich particles featured a high stability suppressing the sinter-induced catalyst deactivation.

In a recent experiment at beamline P07 (DESY) we combined for the first time HESXRD with Planar Laser Induced Fluorescence (PLIF), optical LED Surface Optical Reflectance (SOR) and in-situ Mass Spectrometry (MS) to study self-sustained reaction oscillations during CO oxidation over Pd(001). This allowed, with sub-second time resolution, for correlating the structure (HESXRD, SOR) to the sample's CO_2 production (PLIF, MS). Our data show that the oxidation and reduction of (111)-oriented Pd islands on top of an epitaxial PdO(101) oxide layer, previously reported under reducing conditions close to UHV, play a crucial role in the underlying oscillation mechanism.