Characterization of strong metal–support interaction (SMSI) using X-ray standing waves (XSW)

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Supported metal catalysts have applications in fuel cells, fine chemical production, and emission control, to name a few [1]. SMSI is a phenomenon observed in supported metal catalysts, by which reducible metal oxide supports can form overlayers over the active metal nanoparticles (NPs) when treated with hydrogen (H_2) at elevated temperature [2]. SMSI can lead to loss of activity, but if the extent of coverage is controlled, the decoration of the active phase can bring unique catalytic properties. Studying the formation of metal oxide mono- or multilayers on the surface of NPs is usually done using high-resolution electron microscopy, which only focuses on one or a few particles at a time. To unravel SMSI on ensembles of NPs, element-sensitive techniques are needed, able to measure nanoscale changes in atomic profile.

X-ray standing wave (XSW) techniques are suited for this, as they can measure changes in atomic distribution profile at the sub-nanometer scale by measuring fluorescence signal. Here, we study a model catalyst system based on Co NPs supported on the reducible oxide TiO_2, relevant e.g. for CO_2 hydrogenation and Fischer-Tropsch catalysis. To achieve maximum sensitivity towards atomic movements of the TiO_2 layer, a multilayer mirror (MLM) of MoN/Si_3N_4 with thin (~ 3nm) TiO_2 layer on top was synthesized to generate XSW. Co NPs of ~ 4 nm in diameter were deposited on top of the TiO_2 layer by spark ablation followed by mass selection. The samples were reduced under H_2/N_2 at 450°C for 1 hour and characterized by a combination of X-ray reflectivity and XSW. The results of the first measurements and indication of SMSI will be reported.

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2. S. J. Tauster and S.C. Fung, Journal of Catalysis 55, 29-35 (1978).

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