

CatLab Lecture Series hosted by FHI and HZB

Friday, November 17th 2023, 10:30-12:00

BESSY II, Seminar Room at the Entrance, Albert-Einstein-Straße 15, Berlin Adlershof

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Operando Electron Microscopy

Heterogeneous catalysis is considered one of the key technologies in prospective energy conversion scenarios. Yield, efficiency, and lifetime of heterogeneous catalysts will become of utmost importance and the demand of novel high-performance catalysts fulfilling the above-mentioned criteria will rise tremendously. To cope with the prospective high demand for these functional solids, current catalyst development approaches that are based on empirical optimization may become insufficient and should be replaced by knowledge-based catalyst design strategies.

This requires a detailed, scale-bridging understanding of the structure of the entire catalyst system. However, a static structural understanding would be insufficient as catalysts are metastable compounds and undergo structural changes under catalytic working conditions. The extent of the changes depends on the local chemical potential. As such the local chemical potential influences the structures of the active sites and thus the catalytic performance. To complicate the problem, the structures of the active catalysts are often only stable under working conditions and in order to analyse them, investigations under working conditions are required in which structure and performance can be directly correlated, so called operando measurements.

In some cases, less than 1% of the accessible surface area is active and, thus, active sites are a very local concept for describing the functioning of a catalyst. Besides the local chemical potential, their structures also depend on the real structure of the material, which cannot be detected by structural averaging techniques. To capture these local structural details, electron microscopy is the method of choice.

In this lecture I will introduce the scale-bridging use of *operando* electron microscopy focusing on thermal gas phase reaction. Furthermore, I will show the potential and possibilities in capturing the working structure of heterogeneous catalysts and discuss the limitations of the techniques for catalysis research.