

### ***New insight from X-ray diffraction studies of materials under operative conditions.***

Many present and future technological devices are depending of functional materials (inorganic and organic) where it is important to investigate the relation between structure and physical/chemical properties. It is often not possible to extrapolate from structural properties at ambient conditions; to really understand the materials it is necessary to obtain information at operative conditions. Therefore, detailed characterization at *in situ* and *operando* conditions is of significant interest for a fundamental understanding of reactions and operational mechanisms of functional materials and for development and improvement of existing materials and technology. Many characterization methods are being applied for *in situ* studies and combined information from complementary characterization tools is often necessary to illuminate all aspects of materials properties.

In the lecture I will focus on *in situ* diffraction methods using conventional and synchrotron X-ray radiation as well as neutrons. The development of increasingly more advanced synchrotron X-ray sources has had a tremendous impact on the possibility of performing *in situ* diffraction studies. The high X-ray intensity allows information about even very fast reactions to be extracted. At the same time the tunable wavelength gives the possibility of using high energy X-ray radiation. The high penetrating power means that it is possible to study materials in real operating devices, e.g. catalytic reactors, fuel cells and batteries, instead of only using specially designed *in situ* cells.

I will give examples of *in situ* studies within e.g. materials synthesis, adsorption and ion exchange, fuel cells, catalysts and batteries, where unique information at operating conditions has been obtained. The new MAX IV synchrotron and the coming high intensity neutron spallation source, ESS, in Lund will give very good opportunities for *in situ* and *operando* studies. As an example, the Danish beamline, DANMAX, which will be built at the MAX IV synchrotron, will be designed with particular focus on *in situ* studies using powder diffraction and imaging.