Operando synchrotron X-ray scattering studies of solid-liquid and liquid-liquid interfaces

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Modern synchrotron sources and the emerging free electron lasers provide X-ray radiation of high photon energy and extreme brilliance. These X-ray beams are powerful tools for the structural characterization of complex condensed matter systems on the atomic and nanometer scale. In particular, they enable time-resolved operando studies of deeply buried interfaces, such as solid-liquid and liquid-liquid interfaces, under non-equilibrium conditions and during interface reactions. In the talk examples and novel developments in the methodological capabilities of these techniques will be discussed, focusing on processes at electrochemical interfaces. It will be shown that surface X-ray diffraction allows studying the growth behavior during metal deposition and dissolution at high reaction rates, up to the millisecond scale. Furthermore, operando studies by grazing incidence small angle X-ray scattering (GISAXS) can provide insight into the structural evolution of 3D nanoscopic mounds during electrodeposition and during oxidation/reduction. A very recent development is transmission surface diffraction, which allows direct imaging of the entire in-plane structure of solid surfaces and ultrathin films in liquid environment and is capable of mapping structural properties on the micrometer scale. Operando X-ray diffraction measurements of fluid interfaces will be illustrated by studies of the initial stages of nanomaterial deposition at liquid-liquid interfaces. Finally, the extension of these methods towards ultrafast studies, i.e., X-ray scattering investigations on femto- and picosecond time scales, will be discussed.

Olaf Magnussen performed his graduate research in the group of Jürgen Behm and received his PhD at Ulm University in 1993. After a postdoc at the Physics Department of Brookhaven National Laboratory from 1993 to 1995 he returned to Ulm where he worked at the Institute of Surface Chemistry and Catalysis until joining the Institute of Experimental and Applied Physics of Kiel University as full Professor of Solid State Physics 2001. He is currently spokesperson of “Kiel Nano, Surface, and Interface Science”, one of the four focus areas of Kiel University. His main research interest are the atomic-scale structure and dynamics of condensed matter interfaces, in particular electrochemical interfaces and interface processes, and the development of in situ and operando methods for studies of these systems, specifically surface X-ray scattering techniques and scanning tunneling microscopy.