Operando spatio-temporal imaging of devices and functional nanostructures by X-ray nano diffraction imaging methods

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With the start of the 1st hard X-ray 4th generation synchrotron source ESRF/EBS flux and brilliance hungry methods typically exploiting nanobeams and coherence are gaining momentum in the community of material science. Spatially resolving X-ray diffraction-based tools are of relevance for the characterization of most emerging nanomaterials or electronic devices. While typical samples for these techniques are microelectronic structures, the resolving power has proven to reach down to length scales relevant for catalysis and basic solid state chemistry as encountered in most electrochemical systems. With worldwide efforts in the upgrading or new conception of synchrotron sources, improvements of several orders of magnitude in the throughput of these methods are now at reach and required dedicated beamline design to exploit the significant improvements in spatial resolution but also in the time domain. At the same time, enabling technologies such as X-ray optics and detectors are closing previously existing gaps, further boosting the use of X-ray nano imaging in new fields of science and engineering. Beamline ID01 at the ESRF is specialized on the imaging of strain and structure under Bragg diffraction conditions. Our results following sample evolution either in real time or in stroboscopic mode show the relevance of such new tools in complex experimental environments as encountered in nanotechnology or semiconductor devices where (time-resolved) nano-imaging of strain and structure are of highest relevance.High resolution in reciprocal and real space is now obtained on time scales allowing to follow operando in areas and on timescales ranging from Batteries (seconds to hours) down to sub nanosecond time resolved imaging of functioning electronic devices. Such high time resolution is reached by exploiting the time structure of the synchrotron X-ray beam itself. The talk will present most recent examples covering these areas. These range from surface acoustic wave devices to high performance microelectronic devices as currently developed by our collaborators from industry and academia.