Nanoscale spectroscopy and tomography with the HZB full-field transmission X-ray microscope

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In the nano-age, humans manufacture complex structures atom by atom to design e.g. their specific functionality. Therefore, new tools for the analysis of these structures have to be developed. The HZB microscopy group develops novel methods for X-ray imaging to make use out of the unique interactions of X-rays with matter. For this, X-ray optics for the 10-nm scale characterization of the nanostructure, chemical nature, and composition of materials with high energy resolution are engineered and fabricated. The HZB full-field TXM at the BESSY II U41 undulator beamline allows high spectral resolution of $E/\Delta E=5000$, about 10 nm (half-pitch) spatial resolution and field of views in the range of 10-15 μm [1-4]. With this instrument spatially-resolved NEXAFS studies for material sciences can be performed due to the high energy resolution [5]. Additionally, nano-tomography of cryogenic samples had demonstrated its high potential for life sciences [2].

Conventional spectroscopy methods such as photoemission spectroscopy and X-ray absorption spectroscopy have shown to be particularly well-adapted probes to study electronic properties of nanostructures. However, these conventional spectroscopy techniques typically illuminate areas of 50 μm x 50 μm or larger thus preventing the analysis of a single nanostructure. Spectromicroscopy investigations with nanometer resolution were restricted so far to scanning X-ray microscopes (STXM) or to transmission electron microscopes (TEM) equipped with electron energy loss spectroscopy (EELS). Both methods give no statistical information as they are restricted to small image fields. In contrast, the typical image field in NEXAFS spectroscopy measurements combined with full-field transmission X-ray microscopy (NEXAFS-TXM) is about 10 μm x 10 μm which is large compared to the individual nanoparticle. Therefore, one image stack already contains statistically significant data with nanometer resolution.

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