Multimodal Imaging: 
Phase Contrast and Dark Field in Scanning Probe Microscopy

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The analogies and complementarities of scanning X-ray imaging techniques are described and illustrated with applications from the fields of biomedical science and materials science.

Small-Angle X-ray scattering (SAXS) is sensitive to the average nanoscale structure within the illuminated area. With the advent of 3rd generation synchrotron radiation undulator beamlines, X-ray optics of adequate quality and fast, low noise, high dynamic range 2D X-ray detectors scanning SAXS turned from a proof-of-principle to a routinely applied imaging technique, applied in 2D [1] and 3D [2]. It allows imaging nano scale structures over extended, square centimeter sized areas.

Detector developments as well rendered it feasible to use routinely 2D detectors for scanning transmission X-ray microscopy (STXM) measurements. This allows retrieving differential phase contrast and dark field information together with the absorption image, where the STXM dark field signal is caused by SAXS [1]. STXM with a coherent and overlapping illumination is, e.g., called scanning X-ray diffraction microscopy (SXDM) or scanning coherent diffractive imaging (CDI). With phase retrieval algorithms direct space quantitative electron density information can be obtained at a resolution that is currently limited by experimental parameters to ~150 nm in 3D [3].

(a) (b)

Figure 1: Examples for scanning imaging on different length scales. (a) Scanning SAXS, tomographic section through a rat brain. The section is about 14mm × 9mm large (framing tick marks in 2mm distance). Shown is the integrated scattering cross section for q = [0.05–1.4]nm⁻¹ [2]. (b) Scanning X-ray diffraction microscopy, tomographic section through a mouse femur. The section is about (25µm)² large (scale bar 5 µm long). Shown is the electron density. [3]

References: