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Synchrotron-based Tomographic Microscopy: fast, high-sensitive and high-resolution 3D imaging at the micron and nano scale

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Synchrotron-based Tomographic Microscopy is a powerful technique for fast non-destructive, high resolution quantitative volumetric investigations on samples of diverse nature. At the Swiss Light Source of the Paul Scherrer Institut, a beamline for TOmographic Microscopy and Coherent rAdiology experiments (TOMCAT) has been recently put into operation. This beamline gets synchrotron light from a 2.9 T superbend and the main optical component, a Double Crystal Multilayer Monochromator, covers an energy range between 8 and 45 keV. The standard TOMCAT detector offers field of views ranging from 0.75x0.75 mm2 up to 15x15 mm2 with a theoretical pixel size of 0.37 microns and 7.4 microns, respectively. The beamline design and flexible endstation setup make a large range of investigations possible. In addition to routine measurements which exploit the absorption contrast, the high coherence of the source also enables phase contrast tomography, implemented with two complementary techniques based on a modification of the Transport of Intensity method and grating interferometry. In-situ experiments are also routinely conducted. Typical acquisition times for a tomogram are in the order of few minutes, ensuring high throughput and allowing for semi-dynamical investigations. Raw data are automatically post-processed online and full reconstructed volumes are available shortly after a scan with minimal user intervention.

This talk gives an overview of the TOMCAT beamline introducing different microtomographic approaches (in-line imaging, full-field microscopy, phase contrast and dark-field imaging) and discusses a selection of applications of this versatile technique in the biology and geosciences. Examples range from the visualization of cellular structures in bone samples to the quantification of vascular micro-architecture in the brain. Other applications go from the high-resolution, non-destructive investigations of the internal structure of invaluable and unique fossilized specimens to the quantitative analysis of pore networks in diverse rock types, for instance for improving oil recovery, understanding element mobilization by hydrothermal fluids, studying dynamics of volcanic eruptions or refining current contaminant diffusion models. In-situ (e.g. cryotomography) and semi-dynamical (e.g. compression, crack) experiments will also be discussed.