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X-ray tomographic microscopy at TOMCAT: An overview and latest developments

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The TOMCAT beamline at the Swiss Light Source has established itself as a cutting edge hard X-ray tomographic microscopy endstation for experiments on a large variety of samples, such as new materials, biomedical tissues and rare fossils.
We present an overview of the hardware and techniques available to the user community. Absorption and phase contrast imaging with an isotropic voxel size ranging from 0.16 up to 14.8 microns (horizontal field of views from 0.41 mm up to 30 mm, respectively) is routinely performed with mono- (energy range of 8-50 keV) or polychromatic radiation. Phase contrast is obtained either with propagation-based techniques (simple edge-enhancement and/or using phase retrieval algorithms) or grating interferometry. Typical acquisition times are on the order of a few minutes. A sample exchanger and a package of automation tools are available for performing high throughput studies in a fully automatic manner. Custom devices for in-situ experiments can easily be installed on the sample stage. A cryo-chamber and a laser-based heating system are currently available for such experiments.
In addition, novel cutting edge science is frequently performed thanks to the latest improvements in spatial and temporal resolutions. Nanostructures (100 nm) in micrometer-sized samples can be imaged using a full-field hard X-ray microscope, also providing phase contrast capabilities. Dynamic processes (e.g. evolution of liquid foams and physiology in small living animals) can be followed in 3D thanks to the recently commissioned ultra-fast tomographic endstation, which provides sub-second temporal resolution.
Development of new strategies for efficient handling and fast post-processing of large amount of data (up to 8 GB/s) complement the hardware implementation. With an alternative tomographic reconstruction algorithm based on Fourier methods, a 18-fold performance improvement compared to standard Filtered Back-Projection has been achieved with negligible quality degradation. In addition, the entire post-processing pipeline concept is being revised to match the new challenging data rates and enable quasi-real time monitoring of the acquisition process in 3D. Finally semi-automatic quantification tools are also being developed and their potential has been demonstrated on a selection of diverse applications.

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