Multiscale and ultra-fast X-ray phase contrast tomographic microscopy at the TOMCAT Beamline

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At the Swiss Light Source (SLS, Paul Scherrer Institut, Switzerland), the TOmographic Microscopy and Coherent rAdiology experimentTs (TOMCAT) beamline offers multiple X-ray tomographic microscopy end-stations with absorption and phase contrast imaging capabilities: propagation-based tomography [1], grating-based interferometry [2] with directional sensitivity [3] and Zernike Phase Contrast (ZPC) nano-tomography [4]. Sitting on a 2.9T suberbend with a critical energy of 11.1keV, the beamline can be operated in monochromatic mode either with a Double Crystal Multilayer Monochromator (DCMM) with a bandwidth of a few percent or with Silicon (111) crystals providing a bandwidth down to 10^{-4}. Both cover an energy range between 8 and 45 keV [5]. The beamline can also be operated in white-beam mode, providing the ideal conditions for ultra-fast acquisitions, thanks to the in-house developed high-speed X-ray detector GigaFRoST [6]. Several microscopes are in operation, which cover isotropic voxel sizes from 11 microns down to 60 nm, allowing a broad range of research and industrial applications: biology, geology, material characterization, paleontology, etc.

This talk will present the latest achievements realized in terms of instrumentation and software developments. These will be illustrated with the concrete case of the study of hierarchical materials. These materials, which exhibit different structural configurations at several length scales, require a multiscale / multimodal analysis approach for a deep and complete understanding of their properties. At TOMCAT, dedicated protocols have been elaborated to efficiently acquire first full overview scans of a large sample and then locally zoomed-in high-resolution volumes of specific sample areas. With the high versatility of the beamline, these protocols cover in-situ/in-operando/in-vivo setups, with an acquisition speed that can go up to 20Hz with voxel sizes from 1 to 11 micrometers [7]. Additionally, with omnidirectional dark-field sensitivity, the orientation of anisotropic microstructures can be probed over a large field of view in a single shot [3].

These capabilities will be highlighted by recent studies achieved in the fields of biomedicine [8] and material science [3,9].

References

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