FOCUS ON

The future long beamlines of SOLEIL

The NANOSCOPIUM and NANOTOMOGRAPHY "long" beamlines will be dedicated to state of the art hard X-ray nano-imaging techniques. A 2,200 m² extension to the SOLEIL experiment hall will be built during 2012, to accommodate these beamlines.

Modern synchrotron-based hard X-ray imaging opens fundamentally new ways of spatially resolved sample characterization by fully exploiting the coherence of the X-ray beam. It can reach resolution down to 10-50 nm, filling the resolution gap between optical and electron microscopy, and provides quantitative information with high sensitivity on density variation, elemental distribution, and/or chemical speciation. Moreover, the high penetration power of hard X rays enables non-destructive studies of buried structures on intact specimens with large thicknesses. While NANOSCOPIUM will yield scanning images, NANOTOMOGRAPHY is dedicated to full-field techniques.

Why use coherent X-rays?

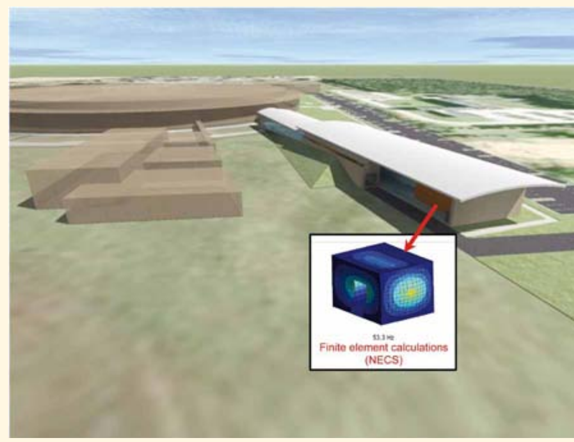
Coherent X-rays not only can be focused into a beam only tens of nm wide; they can also be used to simultaneously generate multiple, complementary images of a given object, in which contrast is generated by different mechanisms. In these "multimodal" imaging techniques, one of the images represents absorption in the sample, analogous to a conventional radiograph. Another maps the change in phase of the radiation, like perturbations in a wavefront. Many interesting samples like biological cells and soft tissue are transparent to X rays, yet interact strongly with the phase, giving very high contrast projection images even in the hydrated state. A third contrast mode, sensitive to scattering, reveals the presence of sub-resolution-size nanostructures and their ordering. In scanning mode, these principles even allow us to simultaneously produce structural images of a sample at "super-resolution" significantly finer than the beam size, using a technique known as "ptychography".

Why so long?

Over 160 meters, NANOSCOPIUM will produce a more coherent and narrow beam in the end-stations than is possible for a short beamline. Focusing optics designed to capitalize upon this long distance will create intense and stable nano-beams. A "secondary source" aperture halfway along the beamline protects against vibrations and drifts, and provides control over the coherence and flux. On NANOTOMOGRAPHY, the beamline length of 200 m not only gives a beam of several cm width for the study of large samples, but also ensures very high transverse coherence of the X rays and, thus, sensitivity to extremely subtle density differences in the objects studied.

Experimental techniques

NANOSCOPIUM, dedicated to scanning techniques in the 5 – 20 keV range, will provide unique research opportunities by combining the analysis of sample chemistry, via X-ray fluorescence and absorption spectroscopy, with structural analysis from coherent imaging at high spatial resolution (= 30 nm) in 2 and 3 dimensions. Elemental distributions and oxidation states can be quantified at the trace level in geological and biological samples for most of the elements starting from Titanium. Fluorescence spectroscopy will target elements as light as phosphorous. Beamline NANOTOMOGRAPHY will operate between 5 and 25 keV and provide 3D volume data over a wide range of length scales, from a resolution of 30 nm (pixel size) to an object width of 40 mm, with a detection limit for density variations down to 0.5 mg/cm³ (0.2 electrons per nm³).



The building extension for the NANOSCOPIUM and NANOTOMOGRAPHY beamlines. The radioprotection hutches must ensure high thermal and vibration stability. Responsible for building construction: P. Eymard.

What is the outlook?

The features, specifications, and new techniques for NANOSCOPIUM have motivated all groups involved to work to make the line available to users by late 2013. For NANOTOMOGRAPHY, a funding application through the EQUIPEX program has been submitted.

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