Some trends of synchrotron radiation X-ray imaging

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Synchrotron radiation (SR) X-ray imaging development was not actually foreseen when planning the ESRF. The document produced at that time ("Red book", 1987) only mention medical imaging, topography and microanalysis maps.

The modern SR sources, coupled with improvements in the detection, optics, and computer power, allowed the emergence of several new forms of X-ray imaging. The availability of very efficient lenses in the hard X-ray range (E>2 keV and up to 100 keV) led to a dramatic progress of the scanning version of X-ray imaging.

Microtomography provides, with a spatial resolution in the micron range (pixel sizes going from 0.3 to 30 µm), three-dimensional images of a wide variety of samples. Absorption microtomography is the more used technique, and allowed, for instance, to study foams and felts, the architecture of snow, the mineralization of bones or fossils in a non destructive way. X-ray imaging attracts to SR facilities scientific communities that were not previously users of large facilities.

In addition the very small angular size of SR sources makes it possible, through the coherence of the X-ray beams, to use phase contrast imaging. This contrast mechanism, coupled with microtomography ("edge detection" or "holotomography" mode), prove to be invaluable when studying, for instance, the porosity of materials, the in-situ damage of composites, or vessels in biological materials. Examples concerning ferroelectric domains (diffraction imaging) or porosities in quasicrystals (transmission imaging) illustrate these capabilities.

Imaging coupled with adequate sample environment (cryostats, furnaces, fields, traction or compression machines, …) can produce unique in-situ and/or real time results. This is illustrated by the observation of the growth of a quasicrystals. The combination of techniques are clearly added values: examples of tomography with markers to study the plasticity and fluotomography for three dimensional chemical mapping, are given.

But the present capabilities of X-ray imaging do not cover all the modern scientific and technical users requirements: the important range for many materials is in the 50 nm to 50 µm. We presently only cover half of this range. On the other hand the temporal resolution is important to follow dynamic phenomena. The possibilities to go to very fast tomography, or very high spatial resolution tomography ("nanotomography project") are briefly discussed.