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ADVANCES AND TRENDS IN HARD X-RAY SR-BASE IMAGING

José Baruchel

European Synchrotron Radiation Facility, BP 220, 38043 Grenoble, France

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X-ray imaging techniques are increasingly used in modern SR facilities [1], and constitute, for instance, one of the five priority topics retained for the Upgrade Program of the ESRF [2]. The common feature to all these techniques is that they apply to inhomogeneous samples, where it is important to measure "locally" a given property, which can be, for instance, the density, the composition, the chemical state or the distortion. These techniques take advantage of most of the photon-matter interactions: absorption, wavefront modification, diffraction, scattering, photoemission, … An increasing part of the experimental results obtained at modern SR-facilities can now be considered, in this way, as "X-ray images" *i.e.* maps in two, or, increasingly, in three dimensions, over the sample of the "local" value of a physical quantity. In this case "local" does not mean atomic level (whereas in some cases atomic information can be extracted from the images) but corresponds to the very important 10^{-3}-10^{-8} m range, where many biological and materials science phenomena occur.

The availability of very efficient lenses in the hard X-ray range (2-100 keV) [3-6] led to a dramatic progress of the scanning version of X-ray imaging (**microbeam based imaging**). This is used for structural and chemically–selective X-ray imaging (high spatial resolution fluorescence maps, or chemical state using energy dispersive micro-spectroscopy) [7, 8].

Techniques are clearly heading towards fulfilling the nanoscale challenge, this implying **higher spatial resolution** X-ray imaging. This is a clear requirement originating from many different scientific communities, which include materials science, but also soft condensed matter, biology, and cultural heritage. High spatial resolution, beyond the detector resolution, is being achieved by nanofocused beams or by lensless coherent diffraction imaging, with a generalized use of phase retrieval procedures, like the iterative determination of the phase of the scattering amplitude in coherent diffraction imaging [9-14].

A second obvious trend is the **improvement of temporal resolution**, made possible by the specific development of X-ray detectors and computing upgrades, which offer new scientific opportunities to follow a system evolving with a short time constant (ms-s range) [15, 16]. Recent developments exploit the **coherence** of the synchrotron X-ray beams for sophisticated phase contrast imaging or coherent diffraction imaging. These techniques rely on improvements of detectors and algorithms, in particular for the reconstruction of "holotomographic" images [17, 18].

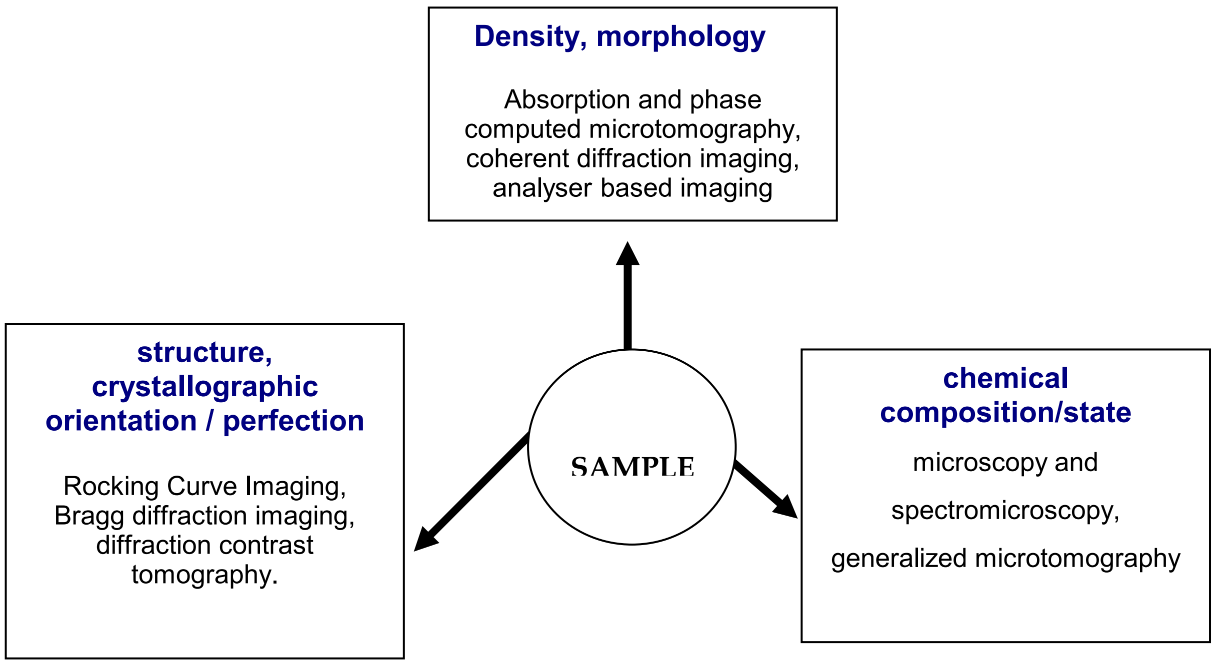

Figure 1: information accessible by using X-ray imaging, and some corresponding SR-based techniques.

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The **combination of techniques** can substantially improve the scientific information that can be obtained on a given topic [19]. An example is Diffraction Contrast Tomography, which provides both the shape and orientation of the grains in a polycrystalline, and the fracture path when this sample is submitted to a tensile stress [20, 21].

These new opportunities will be discussed and illustrated by examples of applications to a wide variety of materials, which reveal features not observable otherwise.

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