Microscopy with Synchrotron Radiation: Phase Contrast Imaging and Micro-spectroscopy

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The advent of very bright third generation synchrotron facilities has lead to incredible advances in microscopy techniques. In particular in the X-ray regime the possibility of using bright radiation sources and the progresses made in X-ray optics fabrication allowed improving the spatial resolution and the chemical sensitivity of synchrotron based instruments.
Phase contrast imaging has been received a lot of attention in the last decades since in many cases it can be superior to absorption contrast imaging. In fact it is the dominant contrast mechanism for short wavelengths: it has a higher throughput in the X-ray regime and it allows reducing the delivered dose.
Several phase-sensitive imaging techniques have been developed in the last half century, the principles of whom will be presented together with some examples and applications.
Moreover in the X-ray regime, the dominant radiation-matter interaction is the photoelectric absorption; this means that since the absorption cross sections differ from element to element, this give rise to a natural contrast mechanism.
Beside the morphological information offered by X-ray imaging (absorption and phase contrast) different spectroscopy can provide speciation and chemical information.
By tuning the energy across a given absorption edge it is possible to investigate the oxidation states of the specific chemical element through X-ray Absorption Near Edge Structure (XANES) spectroscopy.
Furthermore, the incident photons may be absorbed by the atoms releasing an inner shell electron. When the vacancy is filled by an outer electron the energy released can be delivered as an X-ray photon (X-ray fluorescence or XRF phenomenon) or to another outer electron (Auger effect). By analyzing the emitted X-ray photons the chemical elements present in the specimen can be identified.
Recent applications of the above mentioned spectroscopies in the broad life science field will be illustrated highlighting the new opportunities offered by these techniques.