X-ray Microfluorescence Imaging of Samples from Deep Earth to Interstellar Space

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Due to their high sensitivity and non-destructive nature, laboratory and synchrotron radiation based X-ray fluorescence (XRF) micro- and nano-imaging methods play an increasingly important role in many scientific disciplines, including life, material, environmental as well as Earth and planetary science. This work illustrates various applications of these techniques for 2D/3D elemental/chemical imaging with a spatial resolution level reaching 50 nm. Recent developments in laboratory instrumentation include the use of combined approaches of 3D-XRF techniques (XRF-tomography and confocal XRF imaging) with X-ray computed tomography [1]. The quantitative evaluation of XRF data-sets is enhanced by the use of sophisticated Monte Carlo based approaches.

Next to an overview on scanning type of elemental/chemical imaging applications based on the use of laboratory and synchrotron sources, a novel full-field X-ray fluorescence approach will be presented which makes use of a unique two-dimensional energy-dispersive CCD detector developed for non-destructive elemental microanalysis. The advantage of this 'color X-ray camera' (SLcam), produced by IFG/BAM (Berlin, Germany) and PNSensor (Munich, Germany), lies in its ability to record spatially and spectrally resolved images simultaneously by measuring the position of impact and energy of single photons in the energy range of 3-25 keV. The use of such detection system offers new opportunities in XRF microanalysis, especially with respect to 3D elemental imaging, by significantly enhancing the acquisition of 3D elemental data-sets.

Applications of laboratory as well as synchrotron 2D/3D elemental/structural imaging will be illustrated in the field of Earth and planetary science [2,3]. The presented X-ray fluorescence micro/nano-imaging experiments were performed at the XMI laboratory of Ghent University, the European Synchrotron Radiation Facility (ESRF) ID13, ID16B, DUBBLE beamlines and at the PETRA III facility P06 beam line.

References

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[2] Pearson et al., "A hydrous mantle transition zone indicated by ringwoodite included within diamond", *Nature*, 507, 221–224 (2014).

[3] Westphal et al., "Evidence for interstellar origin of seven dust particles collected by the Stardust spacecraft", *Science*, 345 (6198) 786-791 (2014).