THREE DIMENSIONAL NANO-XRF ON COMETARY MATTER RETURNED BY NASA'S STARDUST MISSION

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X-ray fluorescence tomography and polycapillary based confocal XRF imaging using synchrotron radiation are among the most sensitive, non-destructive microanalytical methods which can provide potentially three-dimensional (3D), quantitative information on the elemental distributions in the probed sample volume with trace-level detection limits. Lateral resolution is ultimately limited by the X-ray beam size, which is typically in the 1-10 μm range at a typical second or third generation synchrotron source while sub-micron resolution levels are becoming feasible (down to 30-100 nm) using 3rd generation sources coupled with advanced X-ray focusing optics.

The above XRF-imaging methods been applied for the non-destructive 2D/3D elemental analysis of unique comet micro-particles which were sampled and brought to Earth in the framework of NASA's Stardust mission. These unique micro-particles, which were captured in aerogel, have been examined by a large number of research groups during the preliminary examination period using various non-destructive microanalytical techniques[1-3].

The examined aerogel samples typically contained a single elongated cavity (called track) produced by the impact of a single comet coma particle. We performed multiple experiments on such tracks and their terminal particles at the ESRF beamline ID13 using 2D and 3D nano X-ray fluorescence (XRF) and scanning X-ray diffraction. The XRF measurements have been carried out using two SDD detectors positioned orthogonally with respect to the incoming beam in a symmetrical arrangement relative to the sample. The nanobeam of X-rays was produced by a linear Bragg-Fresnel lens assembly which reduced the dimensions of the beam to the 170-200 nm level.
The presented quantitative micro/nano-XRF results have been obtained by the fundamental parameter and reverse Monte Carlo quantification methods, resulting in concentration distributions for the detectable elements within this unique cometary matter.

References

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