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Confocal X-ray Fluorescence Imaging and XRF Tomography for Three-Dimensional Trace Element Microanalysis

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Owing to their high sensitivity and non-destructive nature, synchrotron radiation X-ray fluorescence (XRF) microtomography and confocal XRF imaging are among the emerging methods which are able to provide three-dimensional, quantitative information on the elemental distributions in the probed sample volume with trace-level detection limits.

With respect to three-dimensional (3D) elemental analysis, XRF microtomography will be compared to novel confocal X-ray fluorescence imaging, which is based on the use of detection side polycapillary optics. In case of the latter, instead of using computed tomography techniques, direct local information from an arbitrary microscopic volume-element within the sample can be obtained (limited in depth by signal self-absorption) by employing a polycapillary half-lens in front of the energy-dispersive detector [1-2]. This optical element restricts the XRF-spectra to be detected only from the microscopic intersection volume of the incoming microbeam and the coinciding focus of the polycapillary lens.

This work demonstrates the development of these techniques towards a three-dimensional, quantitative analytical method with lateral resolution levels down to the 0.5-5 μm scale. Figure 1. shows the schematic representation of both experimental arrangements.
Applications of quantitative 2D/3D micro-XRF will be illustrated by the analysis of microscopic inclusions in natural diamonds, micrometeorites and environmental particles. The presented in-situ X-ray fluorescence microtomography and confocal X-ray microfluorescence imaging experiments were performed at the ESRF ID18F microfluorescence end-station [3]. Based on confocal imaging, fully three-dimensional distributions of trace elements could be obtained (see Fig 2.), representing a significant generalization of the regular 2D scanning technique for micro-XRF spectroscopy.

References

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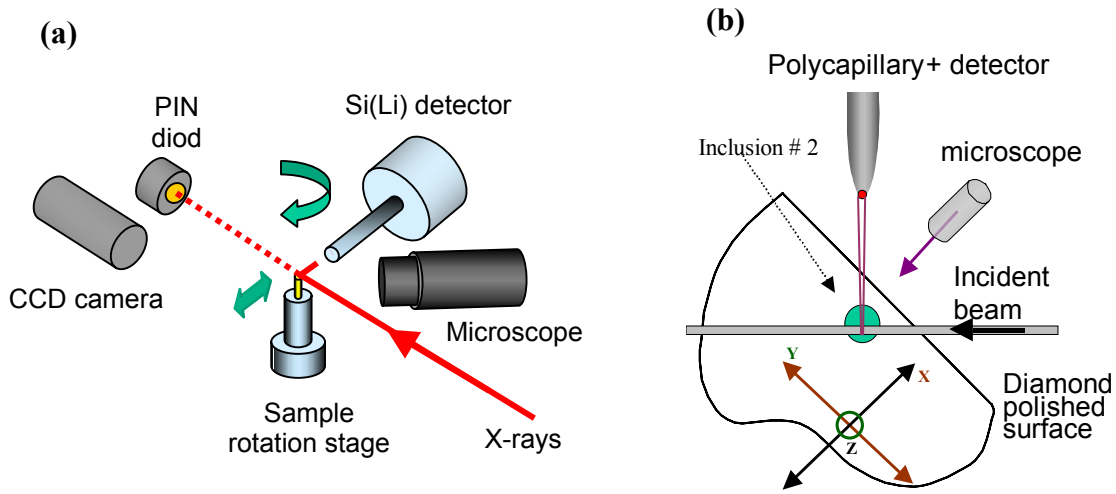

Figure 1. Schematic representation of the XRF-tomography set-up (a) and of the polycapillary based confocal arrangement for 3D-XRF (b) installed at the ESRF ID18F end-station.

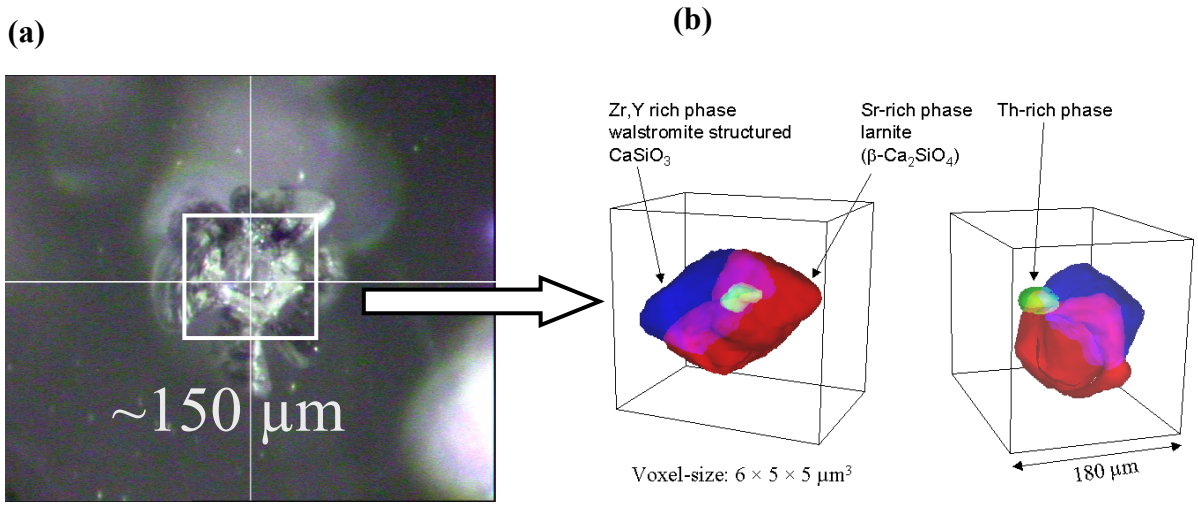

Figure 2. A typical example of the studied diamond inclusions, having a diameter of about 150 µm (a). The depth of this polyphase Ca-silicate inclusion is about 130 µm under the polished surface of the sublithospheric diamond, which originates from the Kankan region in Guinea. The color coded representation of the inclusion is based on the measured chemical composition by confocal XRF microspectroscopy (b).

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