X-ray fluorescence imaging of biological model organisms trapped by laser-based optical tweezers

E. Vergucht[1], T. Brans[2], M. Vandegehuchte[3], F. Beunis[2], M. Burghammer[1,4] and L. Vincze[1]*

[1]X-ray Microspectroscopy and Imaging Group, Ghent University, B-9000 Gent, Belgium
[2]Liquid Crystals and Photonics, Ghent University, B-9000 Gent, Belgium
[3]Laboratory of Environmental Toxicology and Applied Ecology, Ghent University, B-9000 Gent, Belgium
[4]European Synchrotron Radiation Facility, F-38043 Grenoble, France

Owing to its high sensitivity and non-destructive nature, synchrotron radiation based X-ray fluorescence computed tomography (SR XRF-CT) and confocal XRF imaging are emerging methods that provide three-dimensional (3D) information on elemental distributions with trace level detection limits. We propose a new methodology that combines these techniques with optical tweezers (OT) based non-contact sample manipulation for non-destructive micro/nano XRF imaging. In short, optical tweezers use a focused laser beam for trapping a sample within an aqueous environment, enabling non-contact sample manipulation and positioning (Figure 1). The objectives of the new methodology involve the investigation of free-standing biological samples in their natural, aqueous environment. This will lead to the study of organisms close to their natural *in-vivo* state, eliminating the time-consuming and error prone sample preparation steps. In addition, OT setups have the ability to work with multiple optical traps enabling XRF tomography via *in-vivo* sample rotation.

In 2011, Santucci *et al.* reported on the development of a dedicated OT setup for SR probing of trapped biological objects in their natural, aqueous environments [1]. During the past two years, the compact OT setup was further optimised and several biological model organisms were tested for their trapping capabilities. Within a pilot experiment in December 2012, the use of an appropriate sample container with the correct dimensions/composition was evaluated at beamline ID13 of the ESRF. These experiments showed that a cylindrical glass capillary container (200 µm diameter and 10 µm wall thickness, CTS Ltd., UK) is suitable for holding a micro-sample without considerable self-absorption and X-ray scattering effects (Figure 2). In June 2013, a second experiment was performed at beamline ID13 during which the optical tweezers technology was combined with SR micro-XRF *for the very first time*. During this experiment, Chlamydomonas sp. that were exposed to high metal concentrations were manipulated and kept stable using the compact optical tweezers setup and at the same time scanned with SR micro-XRF. The first results from this novel combination of optical tweezers/micro-XRF methodology will be reported in this presentation.

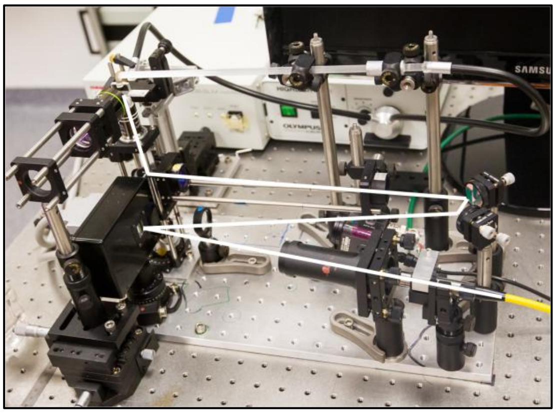

Figure 1: Compact optical tweezers setup with an indication of the laser beam path.

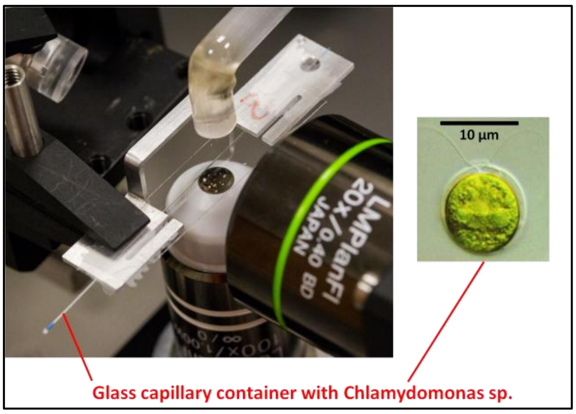

Figure 2: Detail of the sample environment showing a glass capillary filled with Chlamydomonas sp.

References

[1] S.C. Santucci, et al., Analytical Chemistry **83**(12), 4863-4870 (2011).

* Eva.Vergucht@UGent.be