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## Applications of high energy focused ion beams for elemental and molecular imaging in live sciences: micro-PIXE and MeV-SIMS

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By the improvements of the accelerators, ion sources, ion lenses and detectors, high energy focused ion beams are becoming a powerful tool for chemical imaging in life science.

Micro-Proton-Induced X-ray Emission (micro-PIXE) became a technique of choice for tissue elemental mapping in the cases, where high elemental sensitivity, high lateral resolution and quantitative nature of the elemental analysis need to be combined for the tissue analysis. Quantification of the elemental maps is done with supplementary information obtained by Elastic Backscattering Spectrometry (EBS) and Scanning Transmission Ion Microscopy (STIM), providing light element composition and tissue thickness. We will present several representing cases of elemental imaging of biological tissue slices [1], including the samples in frozen hydrated state. We will present the capability for a single cell imaging, where elemental inventories of single cells are determined by picogram (10-12 g) resolution [2].

Combining lateral resolution, high elemental sensitivity and inherent concentration quantification capabilities, micro-PIXE is able to determine the stoichiometry of proteins containing metal atoms by ratio between the number of metallic atoms and sulphur atoms in proteins. The pioneering work was done by Garman and Grime [3] on natural proteins. In the work of Malay et al [4], we applied micro-PIXE to determine the number of gold atoms binding together TRAP protein rings into a synthetic protein cage structure featuring reversible self-organization.

Heavy ions with the energies of several MeV (swift ions) interact with the insulating media exclusively through interaction with the target electrons and create a phonon shock wave, which propagates from the ion impact position through the surrounding material and induces highly efficient desorption of entire ionized biomolecules. Based on this physical phenomenon, a Secondary Ion Mass Spectrometry with high-energy heavy ions (MeV-SIMS) is emerging as a promising Imaging Mass Spectroscopy (IMS) technique for molecular imaging of biological tissue [5]. Selected cases of molecular imaging by MeV-SIMS will be presented [6].

### References:

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