X-ray Fluorescence Microscopy: Advances and Unique Opportunities

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Scanning probe microscopy has had tremendous impact on the scientific community over the past decade, addressing extremely broad and highly relevant scientific questions. To a large extent, this impact was enabled by the development of better nanofocusing, better nanopositioning, improved detector technology and better integration. X-ray fluorescence microscopy (XFM) has been one of the main beneficiaries of these developments, with the ability to image and probe the chemical state of metals present only in trace quantities. For example, in the life sciences, metals play a fundamental role in all known life forms and are increasingly recognized as having a critical impact on human health both in their natural occurrence, via therapeutic drugs, and in diseases such as Alzheimer's or Wilson's disease. In the energy sciences, for example, metal impurities and contaminants in photovoltaic materials can limit device performance, in chemistry the active components in catalysts are typically metals.

Hard x-ray fluorescence microscopy is an ideal technique to map and quantify trace element distributions in these systems. It provides attogram sensitivity for transition metals like Cu, and Zn, combined with the capability to penetrate thick samples. At the same time, the improvements mentioned above are fundamentally changing the way experiments can be carried out, giving us the ability to more completely interrogate samples, at higher spatial resolution, with larger field of view, higher throughput and better sensitivity. In combination with lensless imaging, structural information about the specimen can now be obtained simultaneously at spatial resolutions not limited by the x-ray optics used. We will report on recent advances in x-ray fluorescence microscopy, and discuss methods we have implemented, including fast fly-scanning, methods in data analysis, correlative imaging, and X-ray fluorescence micro-tomography. We will demonstrate their application in several ongoing studies, ranging from the visualization of trace elemental content in a Zebrafish embryo (see, eg, Fig1), to the investigation of plankton to further our understanding climate change.

We will also discuss challenges and opportunities for future scientific applications and instrumentation, in particular with regards to emerging possibilities with diffraction limited storage rings.

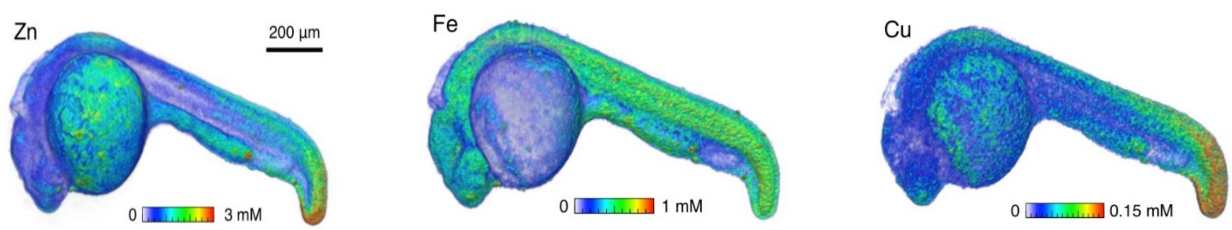

Fig.1: 3D rendering of elemental content (Zinc, Iron, Copper) of a Zebrafish embryo, reprinted from [1].

References

[1] D. Bourassa, S.-C. Gleber, S. Vogt, H. Yi, F. Will, H. Richter, C. H. Shin, C.J. Fahrni (2014) "3D imaging of transition metals in the zebrafish embryo by X-ray fluorescence microtomography", Metallomics, 6(9):1648-55

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