X-ray nanoprobe imaging for biological sciences

P. Cloetens[a], A. Pacureanu[a], Y. Yang[a], J.C. da Silva[a], S. Bohic[a,b], F. Fus[a], M. Hubert[a], M. Langer[a,c], L. Weber[a,c]

[a] ESRF – The European Synchrotron, 38043 Grenoble, France

[b] INSERM U-836 Grenoble, France

[c] Université de Lyon, CREATIS ; CNRS UMR5200 ; INSERM U1044 ; INSA-Lyon ; Université de Lyon 1 ; 69621 Lyon, France

X-ray nano-imaging is a valuable tool for the 3D characterization of the morphology and the elemental composition of biological specimens such as organelles, cells, tissue and model organisms, in their native state. The new nano-imaging end station ID16A-NI of the ESRF combines coherent imaging techniques and X-ray fluorescence microscopy at the ultimate spatial resolution. This enables unprecedented quantitative studies for biological sciences.

High-brilliance X-ray beams focused down to nanometer sizes open new possibilities to tackle major challenges in biology and biomedical sciences. The Nano-Imaging beamline ID16A-NI aims at the quantitative 3D characterization at the nanoscale of the morphology and the elemental composition of specimens in their native state through the combination of coherent imaging techniques and X-ray fluorescence analysis. Coherent imaging techniques map quantitatively the electron density distribution in the sample. Three such techniques are used and actively developed at ID16A-NI: magnified phase nano-tomography [1], far-field ptychography [2] and near-field ptychography [3]. Complementary to coherent imaging techniques, X-ray fluorescence analysis maps the (trace) element distribution by scanning the specimen through the X-ray nanoprobe. To study metal based drugs, X-ray fluorescence is particularly suited to identify the intracellular compartments targeted by these compounds as a main step towards explaining the drug action mechanisms. In correlative microscopy, X-ray fluorescence analysis and magnified phase imaging are combined to obtain quantitative maps of metal concentration in whole cells [4]. A spatial resolution of a few tens of nm in both imaging methods has been demonstrated at discrete energies of 17keV and 33.6keV. The next big challenge consists in adding a cryogenic environment, crucial to get as close as possible to the native state in life science applications without radiation damage. The final goal for the beamline after Phase II of the ESRF Upgrade Program, which will provide a factor 20 more photon intensity and transverse coherence, is to reach a focus size of 10nm and pave the way to dynamical studies.

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