Contribution ID : **84** Type : **Oral**

Microscopy capabilities at the Australian Synchrotron

Monday, 2 December 2019 12:05 (15)

Microscopy capabilities at the Australian Synchrotron include Infrared Microscopy (IRM) and X-ray fluorescence microscopy (XFM) [1].

Infrared Microscopy or Fourier Transform Infrared (FTIR) spectroscopy can provide spatially resolved spectroscopic information on organic and inorganic compounds. High brilliance synchrotron IR enables high signal-to-noise ratios at spatial resolutions between 3–8 μm, making IRM ideally suited to the analysis of microscopic samples, single cells and complex biological systems. IRM can employ Attenuated Total Reflection (ATR) to enable analysis of more difficult samples, e.g. samples that cannot be microtomed or do not adequately reflect. ATR offers enhanced spatial resolution below the diffraction limit.

XFM can provide elemental and chemical microanalysis across millimeter to nanometer length scales. XFM is ideally suited to quantitatively map trace elements within whole and sectioned plant, biological specimens and environmental samples. High elemental sensitivity coupled with deep penetration allows investigation of diverse samples *in situ* or under environmental conditions. Elemental maps can be acquired rapidly which enables higher-dimensional studies including fluorescence tomography [2], X-ray absorption near edge structure (XANES) imaging, and XANES tomography. The speed and efficiency of the technique ensures the lowest possible dose and can avoid radiation damage.

Transmission FTIR spectroscopy was used to examine single live cells in aqueous media [3,4]. Bone disease was studied by examining bone quality after drug treatment using reflectance IRM [5,6]. Insights into lipid composition of brain neurons in brain tissue without the need for staining have been provided by macro ATR-FTIR [7].

X-ray fluorescence XANES imaging investigated in vivo coordination environments of metals in biological specimens [8]. Copper coordination chemistry within *Drosophila melanogaster* was visualised with fluorescence XANES tomography [9]. XANES imaging can be applied to fresh and hydrated plants, e.g., selenium speciation imaging in wheat and rice roots and leaves [10].

High-resolution coherent imaging at XFM brings together X-ray ptychography, spectroscopy and X-ray fluorescence to reveal morphology and speciation at nanometer resolution [11].

Increasingly, researchers use the combined capabilities of IRM and XFM to provide powerful correlative analysis, e.g. to provide understanding of the chemical and elemental composition of latent fingermarks. [12].

Future microscopy capabilities include the BRIGHT Nanoprobe beamline providing versatile X-ray microscopy with sub-70 nm spatial resolution.

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Speakers Gender

Male

Travel Funding

No

Level of Expertise

Expert

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No

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Session Classification : Session 2

Track Classification : Technique Development