Spectromicroscopy Beamline

Spectromicroscopy is a combination of spectroscopy (the analysis of the way different wavelengths of light interact with matter) and microscopy (the imaging of matter on a scale smaller than the human eye can resolve). Techniques available to conduct soft X-ray studies (within the energy range of 130-2500 eV) on this beamline include scanning transmission X-ray microscopy (STXM) and X-ray photoemission electron microscopy (X-PEEM). These techniques are of particular use in the research of materials, semiconductors, surface studies, magnetism, life sciences, and environmental science.
In STXM, a Fresnel zone plate is used to focus monochromatic (single wavelength or energy) X-rays to a small spot size (~30 nm) (Illustration below). The sample is raster scanned (moved across the beam) through the focal point while detecting transmitted photons. This microscope can be operated under near atmospheric pressure and therefore, ideal to study wet and dry samples. While the technique is mainly bulk-sensitive, as samples tend to be very thin to allow adequate transmission in the soft X-ray region, surface adsorbed species can often be detected.

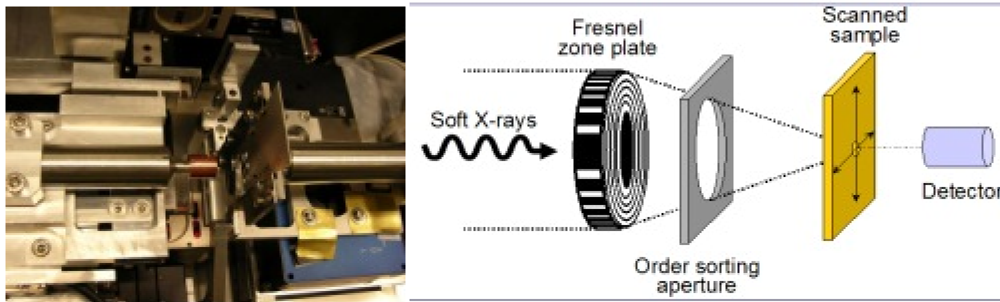


Image and schematic of the STXM.

An example of this technique put to use is determining how chemical treatment of flax fibres affects their structure and composition (Oraji et al.- CLS Activity Report 2008). This research revealed significant structural and compositional changes between treated and untreated flax fibres, such as cracks and discontinuities in the treated fibres, which may have an impact on the quality of bio-composites produced from those materials.

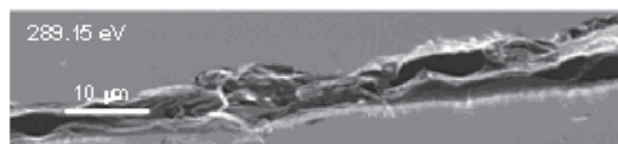
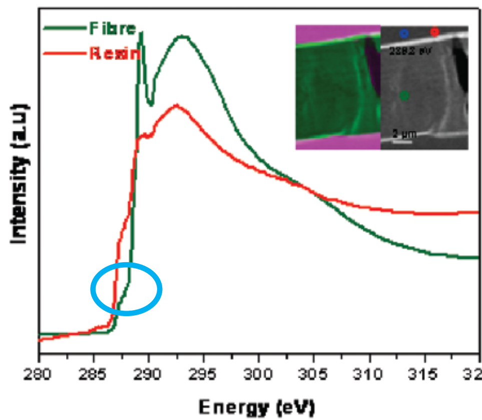
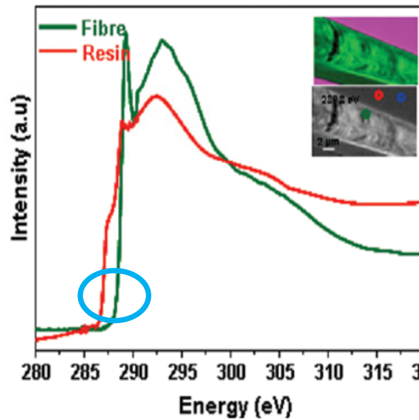


Image of untreated flax fibre (CLS Activity Report 2008)

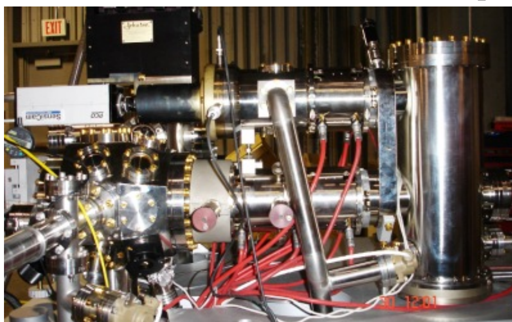




NEXAFS spectra and compositional map of an untreated (left) and chemically treated (right) flax fibre section (Oraji et al., CLS Activity Report 2008). Note the differences in the spectra (circled in blue) and in the images indicating a difference in the chemical composition and structure of the untreated and treated fibres.

In X-PEEM, electrons emitted from an excited atom of the sample by the incident X-rays are imaged with a spatial resolution of ~50 nm (below). The sample environment in this microscope is an ultrahigh vacuum, and samples must be conducting and extremely flat. This surface sensitive (typical sampling depth is 5-10 nm., full field imaging technique features two contrast modes:

1) X-ray absorption spectroscopy (NEXAFS) - images are generated by varying the X-ray photon energy incident on the sample.
2) Photoelectron spectroscopy (XPS) - images are generated by scanning the kinetic energy of the electrons emitted from the sample while keeping the X-ray photon energy fixed.



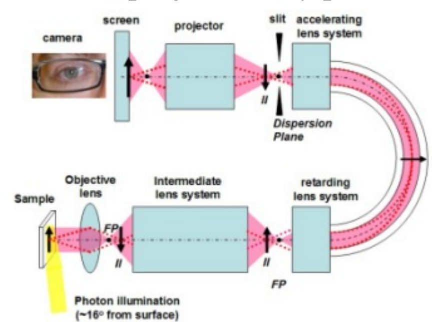
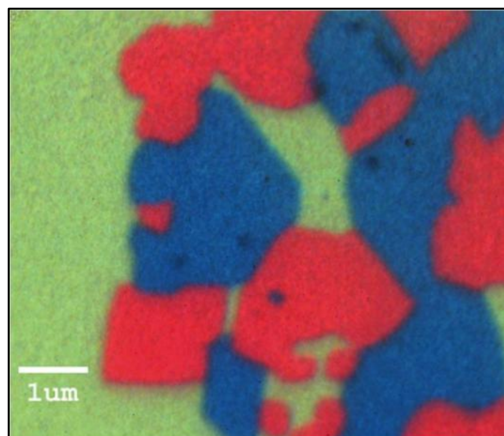


Image and schematic of the X-PEEM



This image shows the location of chromium (red), iron (green), and nickel (blue) on the surface of a stainless steel alloy Uday et al. (p 156 Canadian Light Source Activity Report 2008).