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Soft X-ray Spectromicroscopy (SM) Beamline 10ID-1

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Canadian Light Source Inc.

Beamline Overview

Status	Operational – accepting proposals
Source	Apple II type EPU Period: 75 mm
Monochromator	Plane Grating
Spectral range	130 – 2500 eV
End stations	STXM and X-PEEM
Flux	STXM: 10^8 ph/s in 50 nm spot PEEM:10^{12} ph/s in 50 µm spot
Resolving power	3000, can reach >10,000
Spot size	STXM: 30 nm X-PEEM: 20 µm (50 nm resolution)

Beamline Team

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Introduction

The soft X-ray Spectromicroscopy (SM) beamline consists of an APPLE II type Elliptically Polarizing Undulator (EPU), a plane grating monochromator (130 – 2500 eV), focusing optics, and two microscopes – a Scanning Transmission X-ray Microscope (STXM) and an X-ray Photoemission Electron Microscope (X-PEEM) on separate branch lines. The EPU provides circularly polarized light (up to 1000 eV) and fully plane polarized light (130 to 2500 eV) with polarization adjustable from +90 to -90°. The STXM provides 10^8 ph/s at a spatial resolution of 30 nm. The X-PEEM provides full field imaging at ~50 nm spatial resolution, based on an illumination of 10^{12} ph/s in a 50 µm spot.

The state-of-the-art performance of the SM beamline and endstations include: spatial resolution: ~30 nm; spectral resolution: E/ΔE ~10,000; temporal resolution: ~200 ps (in a special system for magnetization dynamics measurements) [1]. The beamline re-commissioning was completed in January 2009 after a temporary shutdown for the installation of shared components with the neighbouring REIXS beamline 10ID-2, and re-entered regular operation with the general user program in February 2009. The scientific highlights and progress on new technique developments such as humid cell, wet cell, and tomography are highlighted in this article. The scientific highlights from X-PEEM are reported separately[2].

Science

During February to June 2009, the beamline (only open ~4 days a week to accommodate construction of the REIXS beamline) was used by six beam team (BT) and nine general user (GU) groups. With the beamline completely open from July, the number of GU groups increased to 16. Table 1 summarizes some of the scientific projects conducted by BT and GU groups. The scientific program of the beamline is well balanced with the three major research pillars of CLS, namely materials, environment, and life sciences. Two publications in 2009 that used the beamline made it to journal cover pages in Environmental Science and Technology [3] and Angewandte Chemie International Edition [4] (see Figure 1) and were featured as CLS science highights.

New and notable projects that started in 2009 are: X-ray magnetic circular dichroism (XMCD) of individual magnetosomes [5], XMCD of bio-nanomagnetic spinels and magnetic semiconductor materials, investigation of acid leached pyrite surfaces [6], sulphur globule speciation in bacterial cells [7], sulphur metabolism in acid mine drainage [3], iron speciation in clay minerals, effect of minerals in soils over carbon sequestration [8], sorption of phenanthren to black carbon particles [9], selenium speciation in biofilms, study of biopolymers in seeds [10], the effect of antimicrobials on microorganisms, novel materials [11], and nanomaterials in human tissue.

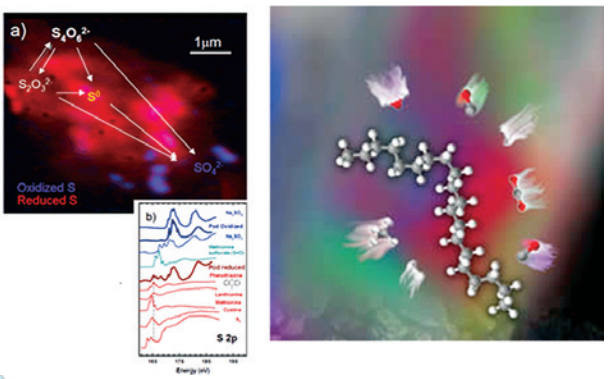

Figure 1: (left) Sulphur metabolism in acid mine drainage; (right) Model of different forms of iron during a catalytic reaction. (Reproduced from: http://www.lightsource.ca/media/S-bacteria.php and http://www.lightsource.ca/media/catalyst_particle.php)

Instrumentation and Research

Table 1. BT and GU research projects at CLS-SM in 2009

PI	Title
Materials Science	
A.P. Hitchcock (McMaster)	X-ray magnetic circular dichroism of individual magnetosomes
A. P. Chandra (South Australia)	A PEEM and NEXAFS study of acid leached pyrite surface
B. van Waeyenberge (Max Planck Institute)	Fast vortex core dynamics in magnetic nano structures
F. De Groot (Utrecht)	In-situ X-ray spectromicroscopy of iron-oxide Fischer-Tropsch catalysts
M. Pézolet (Laval)	Mapping orientation in silk fibres by STXM
S.G. Urquhart (Saskatchewan)	XPEEM studies of phase segregation in Langmuir-Blodgett films; TEY-STXM
V. Coker (Manchester)	STXM analysis of bio-nanomagnetic spinels
Y. Mozharivskyj (McMaster)	XMCD of magnetic semiconductors for spintronics
Environmental Science	
A. Prange (Bonn)	Speciation of sulphur globules in bacterial cells at the S 2p edge
B. De Gregorio (U.S. Naval Research Lab)	Stardust and meteorites: studies of Primitive Extraterrestrial Organic Matter
C. Rivard (France)	Iron speciation in clay minerals under anoxic conditions
J. Lawrence (NWRI)	Mapping antimicrobial agents and their effects on bacterial biofilms
J. Lehmann (Cornell)	Mineral control over carbon sequestration in soil
K. Norlund (McMaster)	Microbial sulphur metabolism in acid mine drainage
M. Obst (Tuebingen)	Sorption of phenanthren to black carbon particles
I. Pickering (Saskatchewan)	Selenium speciation in bacterial biofilms
Life Science	
C. Gaillard (INRA)	Correlative microscopy of biopolymers in seeds
D. Korber (Saskatchewan)	Effect of anti microbial agents on wild and mutant type *Escherichia coli*
J. Gardella (SUNY Buffalo)	Spatial and chemical mapping of a biodegradable polymer thin films
J. Wang (CLSI)	3D chemical and elemental imaging of biological samples by STXM tomography
K. Kaznatcheev (BNL)	Extended soft x-ray dichroic measurements of large molecules
M. Ryan (Manchester)	Compatibility of nanomaterials in human tissue near hip replacements
S. Turgeon (Laval)	Plasma Deposited Fluoropolymer Coatings for Stent Applications

The development of instrumentation and techniques for humid cell, wet cell, tomography, and total electron yield (TEY) in STXM are actively pursued in collaborations of beamline staff with beam team members. Soft X-ray tomography is able to generate 3D chemical mapping and localized information on materials, biological and environmental samples [12]. The development of a controlled humidity cell and a novel wet cell enhances the capability to study the effect of humidity on different samples and to study biological samples in their native forms [13]. The TEY capability with STXM will enable us to determine the surface and bulk properties of samples simultaneously while exploiting the high spatial resolution of the STXM [14].

Outreach Activities

The beam team and beamline staff members actively participate in outreach activities each year. During 2009, Grade 11 and 12 students from Avonlea School in Saskatchewan used the beamline to study the "Effect of UV light on Plant Cells" by exposing canola plants to UV light and determined the structural and chemical changes to canola leaf cells using STXM.

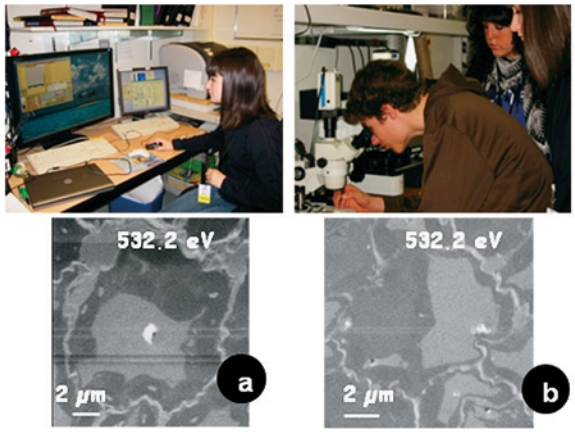

Figure 2: (Top row) Avonlea School students learning to use optical and STXM microscopes at the beamline; (bottom) X-ray images of UV exposed (a) and unexposed (b) canola leaf cells recorded at the O 1s edge showing differences in the morphology and composition.

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