Combining Synchrotron Infrared and X-Ray Micro-Spectroscopy and Imaging Workshop

May 22, 2002

One of the most well attended workshops at the meeting was entitled "Combining Synchrotron X-Ray and Infrared Imaging and Microspectroscopy."

The goal of the workshop was to introduce and describe the many micro-spectroscopy and imaging techniques available at the NSLS, including infrared (IR) micro-spectroscopy, hard x-ray microprobe, Scanning Transmission X-ray Microscopy (STXM), x-ray micro-diffraction, diffraction-enhanced imaging (DEI), and x-ray micro-tomography. The workshop provided unique insight into why the NSLS is so well suited for these techniques.

The synchrotron light produced at the NSLS is 1,000 to 10,000 times more intense than that produced at conventional laboratory sources. The light is also very highly collimated and covers a broad spectra range, from x-ray wavelengths as small as 0.1 angstrom to the far-infrared, with wavelengths longer than 10^7 angstrom.

These characteristics mean that smaller, more intense beams can be produced, giving scientists the capability to produce images of extremely small or dilute samples, determine elemental or molecular concentration gradients, and probe the chemical states of elements and compounds in a variety of materials with very high spatial resolution.

The workshop gave the attending NSLS users a practical sense of the individual techniques available to them and specific examples of how such techniques are being used and combined by users to solve complex scientific problems in a variety of fields.

During the morning session, six speakers described the ins and outs of each technique.

Geochemist Antonio Lanzirotti, from the University of Chicago, presented a discussion of the X26A beamline hard x-ray microprobe. With an emphasis on Earth and Environmental Sciences, X26A allows users to quantify elemental abundances of materials in situ with detection limits often better than one part per million (ppm) and at a spatial resolution of 10 micrometers or better.

Physical chemist Jean Jordan-Sweet, from the IBM Research Division's Thomas J. Watson Research Center in Yorktown Heights in New York, introduced the attendees to the uses of micro-diffraction imaging at the X20 beamlines, showing how these instruments can be used to study interfacial strain caused by residual stresses in materials and for real-time characterization of electro-migration effects with a spatial resolution as small as 2 μm.

Workshop Participants

Physicist Chris Jacobsen, from the State University

of New York in Stony Brook, gave a broad and thorough overview of soft x-ray microscopy studies at the X1A beamlines. With an energy range of 100-1000 eV, these beamlines are optimized for imaging and spectroscopic analysis of low-Z elements such as carbon and oxygen with a spatial resolution as small as 30 nm. They are thus very well suited to the study of single biological cells.

John Dunsmuir, from ExxonMobil Research & Engineering Company (EMRE) in Fairfax, Virginia, discussed the uses of x-ray absorption micro-tomography (XMT) and how such studies are conducted at beamline X2B. With image resolutions approaching 1 μm, XMT analysis of medical, industrial, and earth materials gives users the ability to image the internal structure of macroscopic objects without having to physically dissect the object.

NSLS physicist Zhong Zhong highlighted the recent and dramatic advances in Diffraction-Enhanced Imaging (DEI) at the X15A beamline. DEI dramatically enhances the ability to image and contrast soft tissue in ways not currently possible using techniques such as Magnetic Resonance Imaging (MRI) and Computed Tomography (CT) imaging. In the field of clinical imaging, particularly with respect to mammography, it's clear that DEI can provide remarkable sensitivity compared to standard radiographic techniques.

NSLS chemist Lisa Miller gave an informative presentation illustrating most effectively how the 500-1000 times greater brightness of the infrared (IR) source on the VUV-IR ring in comparison to standard laboratory sources allows IR studies, often using commercial infrared microscopes, to be done with smaller spot sizes and higher throughput. Miller showed that these improvements allow for better resolution of chemical components in a wide range of materials, including plant and animal tissue, polymers and laminates, and geological samples.

The six speakers of the afternoon session focused on various applications, emphasizing the complementary information that can be obtained by using multiple techniques.

BNL environmental scientist Keith Jones presented a study of the properties of sediments in the New York/New Jersey harbor using XMT, hard and soft x-ray micro-spectroscopy, and Fourier-Transform Infrared (FTIR) techniques.

Biologist Lila Graham, from the Children's Hospital in Boston, presented the results of a study of the nature of bone mineralization using FTIR, hard x-ray micro-spectroscopy and micro-diffraction techniques.

Physicist George Flynn, of the State University of New York in Plattsburgh, provided insight into the elemental mapping of interplanetary dust particles that he obtained by using hard and soft x-ray micro-spectroscopy, FTIR, and XMT techniques.

Geophysicist Russell Hemley, of the Carnegie Institute in Washington, DC, presented studies of high-pressure materials and compounds using FTIR and x-ray micro-diffraction techniques.

Physicist Marco Di Michiel, of the European Synchrotron Radiation Facility (ESRF) in Grenoble, France, presented results of a study of fast high-energy x-ray tomography and site preferences for metal uptake in minerals, using hard x-ray micro-spectroscopy.

Geologist Richard Reeder, of the State University of New York at Stony Brook, presented his latest results on site preferences for metal uptake in minerals, obtained using hard x-ray micro-spectroscopy.

A "Guidebook of Micro-spectroscopy and Imaging Techniques at the NSLS" was distributed to the attendees at the end of the workshop and can be downloaded online at:
http://nslsweb.nsls.bnl.gov/nsls/pubs/nslspubs/imaging0502/imaging0502.htm

-Lisa Miller and Antonio Lanzirotti