Mid-Infrared Beamline 01B1-1

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Beamline Overview

Status	Operational
Source	Bending Magnet
Spectrometer	Bruker IFS66V/S FTIR
Spectral range	4000 - 600 cm^{-1}(< 0.5 eV)
Flux	10^{13} Photons/s/0.1%BW
Brilliance	10^{16} Photons/s/0.1%BW /mm^2/ $mrad^2$
Resolution	8 – 0.12 cm^{-1}
Spot size	Diffraction limited

Introduction

The mid-infrared (Mid-IR) beamline was conceived as a laboratory for high-spatial resolution spectromicroscopy. It takes advantage of the brightness of synchrotron IR emission to overcome throughput limitations of IR microscopes when operated close to the diffraction limit. As such it is an effective tool for performing spectromicroscopy and mapping experiments on small samples in the micrometer size range.

The beamline has been open to external users since July 2007 (Cycle 6), following a temporary shutdown during Cycle 5 to stabilize the extraction mirror.

Table 1: Beamline 01B1-1 Milestones

2005	Beamline construction; first light and spectra
2006	First microscope experiments
April	Begin commissioning
Oct 2006	Install Active Optics
Feb 2007	Stabilize extraction mirror
Mar	Test active optics: diffraction limited experiments
July	Cycle open to users
Nov	Polarization experiments

Science

The beamline is currently being used for diffraction limited spectromicroscopy and mapping in the mid-infrared region and for photoacoustic spectroscopy in the mid- to far-infrared regions. The user community has a variety of research interests, mostly pertaining to the life sciences. These include research in plant freeze-resistance, environmental chemistry, pathology, fungal biology, animal science, agriculture, food science, and cellular biochemistry. Interest has also been expressed by groups working in material and surface science, chemistry and geology and applications are expected to expand in this direction in the future.

Instrumentation

A research-level Bruker Optics IFS66v/S FTIR spectrometer and a Hyperion 2000 IR microscope operate as the Mid-IR endstation. The Maximum Optical Path Difference (MOPD) of 10 cm allows a maximum resolution of 0.12 cm^{-1}. Most experiments operate with 4 to 6 cm^{-1} resolution. Other intrinsic features include wide spectral coverage, step-scan operation, vacuum operation, and low noise level (~10^{-6} AU). In addition, a photoacoustic cell is available for use in the sample compartment of the spectrometer.

The Hyperion 2000 IR microscope uses 15X, 36X, Attenuated Total Reflection (ATR) and Grazing-Incident Reflection (GIR) objectives. The microscope also offers users the option of performing reflection or transmission experiments and mapping of areas of interest on the sample. A variable temperature stage (-190° to 300° C) is available to users.

Layout

The beamline extracts light from port 01B1-1. IR light is steered to the IFS66 interferometer using a combination of 4 planar and 3 ellipsoidal gold-coated mirrors. A 0.5 mm thick, 20 mm diameter diamond window separates the Ultra High Vacuum (UHV) regime of the storage ring from the Rough Vacuum (RV) regime existing in the remaining portion of the Mid-IR beamline vacuum system. A 6 mm thick, 50 mm diameter KBr window separates the RV regime of the beamline from that of the spectrometer. A schematic of the layout of the Mid-IR beamline is displayed in Figure 1.

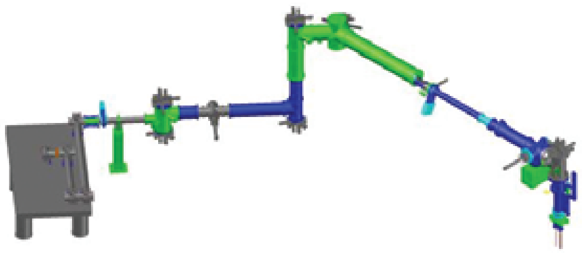

Figure 1. Optical layout of beamline 01B1-1. Connection to the light source is on the right side. On the left side is the optical table with the active optics chicane.

Performance

The installation of an active optics unit, as described in the article by T. May [Techniques and Instrumentation section, this volume], allows for compensation of synchrotron beam drift and stabilization of alignment, with remarkable effects on beamline performance. [1] Commissioning experiments have shown that the signal-to-noise gain relative to a globar source in the 1000-1300 cm^{-1} region approaches three orders of magnitude when tested by restricting the field of view with a 5 μm pinhole in the sample plane. Such performance allows spectromicroscopy measurements and mapping with diffraction limited spatial resolution. Figure 2 shows the mapping of a 1951 USAF resolution target in reflection, using a 36X magnification Schwarzschild. Resolution of target elements follows the wavelength dependence expected for a diffraction limited system.

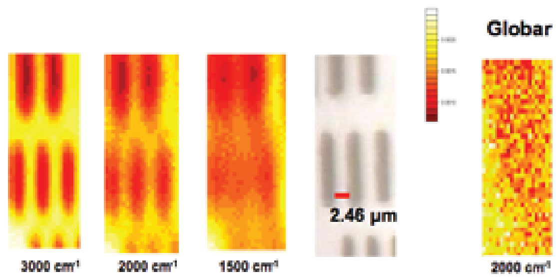

Figure 2. Reflection infrared maps of a 1951 USAF resolution target. Maps are reported at different wavelengths. Loss of resolution of element bars is observed at a wavelength of approximately 2.5 μm, as expected for diffraction limited resolution when using an objective with 0.5 numerical aperture.

Beamline Design and Beamline Team

Table 2: Beamline Design and Beamline Team

Tim May	Beamline Design - CLS
Luca Quaroni	Beamline Scientist - CLS & University of Manitoba
Kirk Michaelian	Leader - CANMET Energy Technology Centre, Devon, AB
Kathy Gough	University of Manitoba
Bernard Juurlink	University of Saskatchewan
Kaiser Ali	University of Saskatchewan
Colleen Christensen	University of Saskatchewan
Eric Pellerin	NRC-Institute of Biodiagnostics, Win-nipeg, MN
Farid Bensebaa	NRC-Institute for Chemical Process and Environmental Technology, Ottawa, ON
Tom Ellis	CLS
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Conclusion

Construction of the beamline is complete. Commissioning experiments have been performed to test for diffraction limited performance, signal-to-noise levels and photoacoustic experiments [2]. Final commissioning, involving the ATR and GIR objectives, is expected to continue through the first half of 2008.

References

1. May, T., Ellis, T. and Reininger, R. 2007, Mid-infrared spectromicroscopy beamline at the Canadian Light Source. Proceedings of 14th National Conference on Synchrotron Radiation Instrumentation. N.I.M.A. 582, 111-113.

2. Michaelian, K.H., May, T.E. and Hyett, C. 2008, Photoacoustic infrared spectroscopy at the Canadian Light Source: Commissioning experiments. Review of Scientific Instruments 79, 014903-1-5.