BEAMLINE SCIENTIST:

**Feizhou He**
feizhou.he@lightsource.ca
306-657-3726

BEAMLINE TEAM LEADERS:

**George Sawatzky**
sawatzky@physics.ubc.ca
604-822-3540

**Alexander Moewes**
alex.moewes@usask.ca
306-966-6431

SCIENCE ASSOCIATE:

**David Muir**
david.muir@lightsource.ca
306-657-3766



# Resonant Elastic and Inelastic Soft X-Ray Scattering (REIXS) Beamline 10ID-2

Feizhou He
Canadian Light Source Inc.

## Beamline Overview

| | |
|---|---|
| Status | Commissioning |
| Source | Elliptically Polarizing Undulator (EPU) |
| Monochromator | Variable Line Spacing Plane Grating Monochromator |
| Energy range | 80 – 2000 eV |
| Flux | $3 \times 10^{11}$~$1 \times 10^{12}$ photons/s/100mA |
| Resolving power | E/ΔE > 5000 |
| Spot size | RSXS: 90 μm × 50 μm RMS<br>XES: 20 μm × 5 μm RMS |

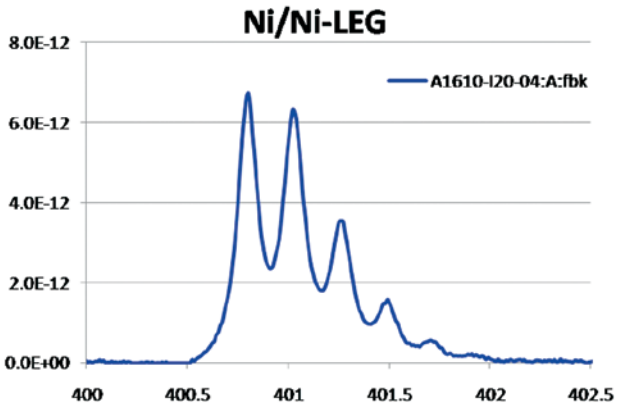


***Figure 1:*** The first spectrum of the REIXS beamline: nitrogen gas phase photo-ionization spectrum.

## Introduction

The REIXS beamline, currently under commissioning, is a soft X-ray scattering facility that soon will provide researchers with a powerful tool to study novel and advanced materials, including strongly correlated electron systems, nano-scale biomaterials, spintronics materials, etc.

The source of the beamline is an Elliptically Polarizing Undulator (EPU) which will produce photons of circular or elliptical polarization, as well as linear polarization in any inclination. The monochromator has one plane mirror and three gratings to cover the energy range from 80 eV to 2000 eV. The beamline is designed to achieve high flux, high brightness, moderate resolution and full polarization control. There are two endstations attached to the REIXS Beamline, for soft X-ray scattering and X-ray emission spectroscopy, respectively.

## 2009 Update

The commissioning of the REIXS Beamline is well underway. The beam reached the endstation in June 2009, and the first spectrum was recorded in July 2009. The scientific commissioning commenced soon after and the first measurement in the RSXS endstation was done in August 2009. The first MCD (magnetic circular dichroism) spectrum was recorded in September.

The REIXS beamline has the capability to accept light from both of the EPUs in straight section 10 of the CLS storage ring. The two beams are spatially separated, and a rotary chopper is used to select which beam reaches the sample in the endstation. When the two EPUs are generating light with different polarizations, rapid switching of the polarization can be realized. The test of this operational mode has been successful.

### The RSXS Endstation

The resonant soft X-ray scattering (RSXS) endstation combines diffraction methods with spectroscopic techniques to develop a new structural characterization method in the soft X-ray regime. The highly monochromatic, coherent, polarized and variable energy X-ray radiation allows us to zoom in on a particular atom in a specific local environment. The extreme sensitivity to local charge, spin and structural changes will allow us to study the interplay of charge, spin, orbital and lattice degrees of freedom in strongly correlated electron systems, and to investigate the phenomena such as superconductivity, charge order, orbital order, and various types of magnetism. The use of circularly polarized X-rays will enable a nanometre scale study of magnetic structure in materials such as monolayer films and multilayers, the formation of magnetic domains and domain walls.

The main scattering chamber of the RSXS endstation is connected to the beamline. It houses a sophisticated in-vacuum 10-motion diffractometer to manipulate the samples as well as to position and switch the detectors. Several types of detectors are available for scattering / reflectivity experiments, and for measuring the electron yield, fluorescence yield and magnetic dichroism.

An offline surface science system (by Omicron) is available for sample characterization. Samples can be analyzed by techniques including XPS, UPS, AES, EELS, STM and AFM.

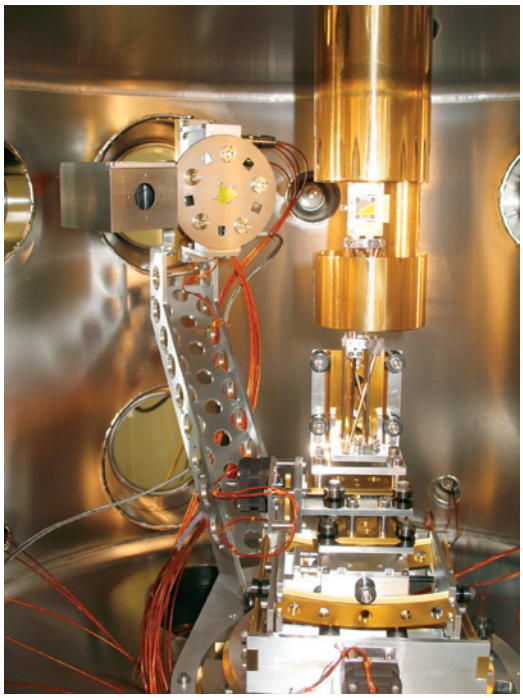

***Figure 2:*** The RSXS endstation: in-vacuum diffractometer and sample stage.

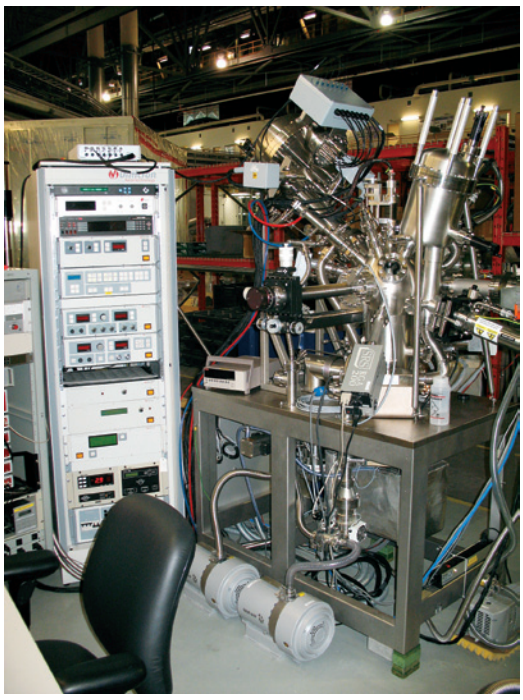

***Figure 3:*** Omicron surface science system.

A MBE preparation chamber, under construction at UBC, will provide all the facilities to grow thin films, to monitor the growth process and to prepare samples.

### The XES Endstation

The X-ray emission spectroscopy (XES) endstation for resonant inelastic scattering will be a synchrotron-based tool to study the electronic structure of new materials. It will allow access to new information on chemical state, electronic structure or best possible synthesis of the systems. This research will ultimately lead to novel devices like sensors with advanced and tailored optical, electronic, magnetic and catalytic properties.

The Moewes group has started the construction of the XES/RIXS endstation. At the core of the endstation is a large custom designed Rowland circle spectrometer. It will use four diffraction gratings to cover an energy range of 50 eV – 1100 eV with good efficiency and resolving powers ($E/\Delta E$) in excess of 2500 at the C, N and O $K\alpha$ emission edges. Two additional gratings, specifically designed to operate in the third diffraction order, will provide resolving powers in excess of 10 000 at those emission edges. The spectrometer will use a high resolution microchannel plate detector, mounted inside a 2 m long vacuum chamber to allow it to reach the large focal distances required by the third diffraction order gratings.

Along with the spectrometer for soft X-ray emission spectroscopy (XES) and Resonant Inelastic X-ray Scattering (RIXS), the endstation will include instrumentation for soft X-ray Absorption Spectroscopy (XAS) using Partial- and Total- Fluorescence Yield (PFY & TFY) and Total Electron Yield (TEY). In addition to the synchrotron light, an electron gun will be available as a secondary excitation source. The sample manipulation system will be capable of heating and cooling from -175°C to 1000°C during experimentation.

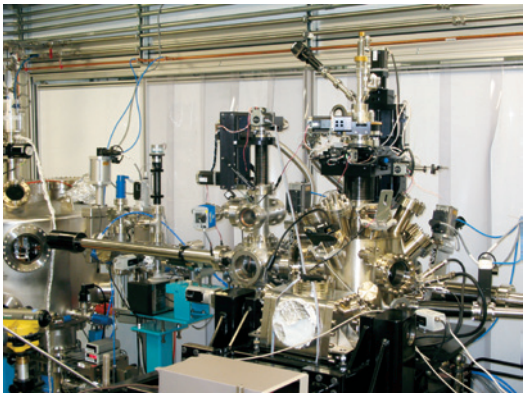

***Figure 4:*** The XES endstation sample chamber and load lock.

A range of in situ material preparation and analysis techniques will be available including heating, cooling, ion bombardment/sputtering, cleaving, LEED and Auger electron spectroscopy.

## Acknowledgements

The REIXS beamline team gratefully acknowledges funding by the Natural Sciences and Engineering Research Council of Canada (NSERC), the Canada Foundation for Innovation (CFI), the Canada Research Chairs program, the British Columbia Knowledge Development fund (BCKDF), Western Economic Diversification, and the Province of Saskatchewan.