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Variable Line Spacing Plane Grating Beamline

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Principal Contacts

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Beamline Overview

Status	Approved and funded as of December 31, 2001
Source	Linear undulator
Monochromator	Variable line spacing plane grating
Spectral range:	
Grating 1	5.5–50 eV
Grating 2	30–140 eV
Grating 3	120–250 eV
Flux	10^{12} photons/s/100 mA
Brilliance	10^{16} photons/mm^2/mrad^2/ 0.1% bandwidth
Resolving power	10^4
Spot size	0.5 × 0.5 mm

Science

This beamline will provide high-flux, high-resolution, low-energy photons (5.5–250 eV) for photoemission spectroscopy and related techniques such as photoabsorption, photodesorption, Auger, reflectivity, luminescence, and fluorescence. The linear undulator will illuminate a variable line spacing plane grating monochromator (VLS-PGM) with three gratings. With its two endstations, each equipped with a photoelectron spectrometer and preparation chambers, it will have all the tools for frontier fundamental research and fast turnaround industrial applications. Some of the planned areas of research are summarized in the following sections.

Studies of the electronic structure of low-dimensional materials

The low energy grating will provide 10^{12} photons/s with an energy range from 5.5 eV to approximately 30 eV at millielectron-volt energy resolution. When equipped with a Scienta analyzer, this beamline will provide an unprecedented capability to conduct photoemission studies of the non-Fermi (Luttinger liquid) behaviour in one-dimensional pseudo nanowires, the pseudo gap in high T_C superconductors, and the spin and charge separation in low dimensional materials (at the Fermi level as well as in the valence band region).

Physics and chemistry of nanostructures, surfaces and thin films

A vast variety of high-tech materials and devices can benefit from the high resolution and high flux of photons of this beamline. Examples include metal overlayers, metal nanostructures relevant to catalysis, metal silicides, semiconductor quantum wires, and quantum dots relevant to optoelectronics. Spin-polarized photoelectron spectroscopy can be used to study magnetic overlayer structures and thin films. Well-defined surfaces and overlayer structures can be studied by using the Scienta analyzer for energy and angle multidetection of photoelectrons. This beamline will also be ideal for analyses of anti-wear coatings, corrosion layers, and tribology films, especially those containing Si, S, P and Cl.

Rapid-turnaround core level analysis with ultrahigh resolution and chemical sensitivity

The medium- and high-energy gratings of the monochromator will provide the widely sought capability for chemical analysis using core levels for a large variety of samples—polymers, metals, semiconductors, ceramics and environmental specimens. The absorption cross-section and core-hole lifetime broadening characteristics are very favourable for the analysis of a large number of elements and core levels. Cross-section optimization using Cooper minima will further enhance the level of chemical sensitivity provided by high-resolution

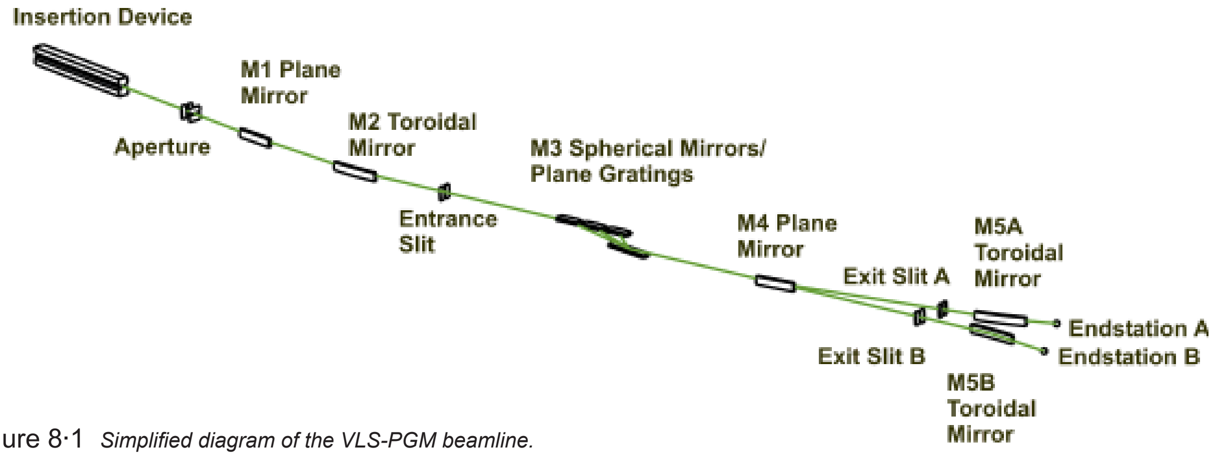

Figure 8·1 *Simplified diagram of the VLS-PGM beamline.*

photoemission. With load locks and a sample preparation chamber attached to the spectrometer as standard equipment, fast-turnaround experiments in photoemission and photoabsorption will be possible at these endstations. The remaining challenge will be to work with non-conducting materials: the implementation of magnetic lens technology should drastically reduce the effects of specimen charging.

Atomic and molecular physics, analytical applications, and PEEM

The Scienta analyzer will be permanently installed on the first branch line as a system for high-resolution photo-absorption and photoemission experiments. The second branch line will be designed to accommodate a variety of custom endstations: these will be temporarily installed as needed. Initially, the endstation suite will include those currently at the CSRF facility (as listed in Table 8·1). The energy range of this beamline will be particularly suited to gas-phase studies of inner valence shells of atoms and molecules. Time-of-flight mass spectrometry and ion-ion coincidence experiments at extremely high resolution will be conducted. Gas-phase photoelectron and absorption spectroscopy and investigations of non-dipole behaviour will also be performed. The Elmitec PEEM (Photo-emission Electron Microscope) described in Chapter 10 may also be mounted for surface microscopy applications when low energy photons are desired.

Table 8·1 VLS-PGM endstation suite at the CSRF

PGM endstations	Scientists responsible
Scienta analyser	Yongfeng Hu
Gas phase absorption	Kim Tan
Surface analysis	T. K. Sham
Time-of-flight system	Adam Hitchcock
X-ray fluorescence	Astrid Jürgensen
XANES (TEY, FY, LY)	Masoud Kasrai; Kim Tan
PEEM	Stephen Urquhart

Performance

The VLS-PGM beamline replaces the Grasshopper beamline presently operating at the CSRF (the Canadian Synchrotron Radiation Facility at the University of Wisconsin-Madison). It will cover the far UV and ultrasoft X-ray energy range—5.5 to 250 eV—and will overlap with the lower range of the SGM beamline. Figure 8·1 is a simplified diagram of the PGM beamline, including the linear undulator source. Figure 8·2 presents the estimated flux at the sample for the machine conditions in 2004, while that for the conditions expected in 2008 is given in Figure 8·3. The design specifications are as follows:

- Energy range will be 5.5–250 eV;
- Source will be an ID with 5.5–250 eV first harmonics;
- ID will share a straight section with the SGM ID;
- ID will be 2 m or less in length;
- Optics will be optimized for 20–100 eV;
- Resolving power will be at least 10 000;
- Beamline will have a real entrance slit; and
- Spot size at the sample position should be less than 0.5×0.5 mm^2.

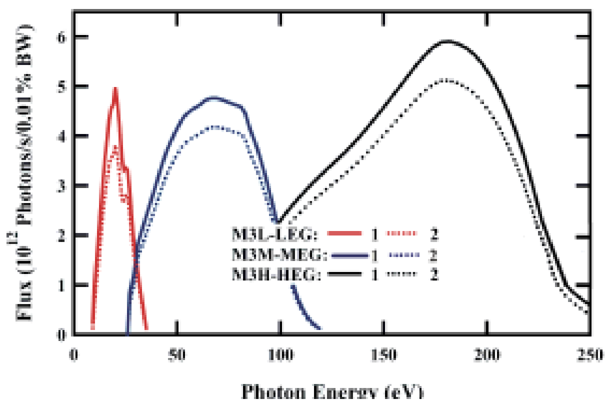

Figure 8·2 *Photon flux expected at the sample position of endstation A (solid lines) and endstation B (dotted lines) at a resolving power of 10 000 under the machine conditions expected in 2004.*

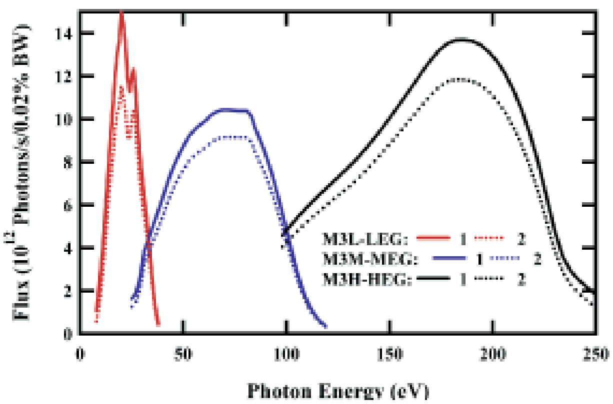

Figure 8·3 *Photon flux expected at the sample position of endstation A (solid lines) and endstation B (dotted lines) at a resolving power of 5000 under the machine conditions expected in 2008.*

Table 8·2 VLS-PGM beamline design and research planning team

Role	Name and e-mail address	Institution	Experience
Beamline Coordinator, Staff Scientist	Ian Coulthard ian.coulthard@lightsource.ca	CLS	VUV spectroscopy; instrumentation (SRC, APS)
Technical Coordinator	Kim Tan ktan2@facstaff.wisc.edu	CSRF	VUV optics; instrumentation (SRC)
Consultant, beamline design	Ruben Reininger ruben@sas-rr.com	Scientific Answers & Solutions (SAS)	VUV optics (SRC, BESSY)
CLS Beamlines Manager	Emil Hallin emil.hallin@lightsource.ca	CLS	Instrumentation; CLS Work Package #6 leader (SAL, SRC, APS)
Beamline Team Leader	T. K. Sham sham@uwo.ca	UWO	Photoemission (SRC, APS, UVSOR, NSLS)
ID design and implementation	Ingvar Blomqvist ingvar.blomqvist@lightsource.ca	CLS	Danfysik; insertion devices
Endstation design and implementation	Yongfeng Hu yhu@uwo.ca	CSRF	VUV; soft X-ray operation (SRC, MAX II, APS)
Consultant, industrial application	Jeff Cutler jeffrey.cutler@lightsource.ca	CLS	Photoelectron spectroscopy; industrial applications (SRC)
Consultant, technical support	Astrid Jürgensen ajurgens@src.wisc.edu	CSRF	Photoelectron spectroscopy; XAFS (SRC, APS)
Ray tracing, optics evaluation	Brian Yates brian.yates@lightsource.ca	CLS	Beamline instrumentation (SRC)
Consultant, frontend and FOE	De-Tong Jiang detong.jiang@lightsource.ca	CLS	XAFS; reflectivity (APS, SRC, SSRL, NSLS)
Consultant, industrial application	Stewart McIntyre smcintyre@uwo.ca	UWO	Director of Surface Science Western
Consultant	Mike Bancroft mike.bancroft@lightsource.ca	UWO; CLS	Photoelectron spectroscopy (SRC); Past Director of the CLS

Table 8·3 CSRF users and potential VLS-PGM beamline team members

Canadian Light Source, SK	I. Coulthard; J. Cutler; E. Hallin
Dalhousie University, NS	M. A. White
U. of Guelph, ON	J. Lipkowski
INRS, QC	D. Guay
NRC, ON	R. Boukherroub; J. Gupta; J. S. Tse
Simon Fraser University, BC	E. D. Crozier
U. of Alberta, AB	R. Cavell
U. of Saskatchewan, SK	K. Mitchell; S. Urquhart; A. Moews; R. Sammynaiken
U. of Toronto, ON	G. S. Hendersen; Z.-H. Lu
U. of British Columbia, BC	G. Sawatzky; T. Tiedje
U. of New Brunswick, NB	J. Neville
U. of Western Ontario, ON	G. M. Bancroft; M. Fleet; M. Kasrai; R. Martin; N. S. McIntyre; W. Nesbitt; T. K. Sham; M. J. Stillman
U. of Waterloo, ON	T. Leung

Beamline Team

Table 8·2 summarizes the beamline design team and the core beamline team members involved in establishing endstation and beamline properties. Table 8·3 lists scientists currently working at the CSRF facility in Madison, WI. It is expected that many of them will be users of the PGM beamline. Milestones for the beamline project are listed in Table 8.4.

Table 8·4 VLS-PGM beamline milestones

August, 2001	Preliminary design
September, 2001	External review report
November, 2001	BT meeting to discuss implementation strategy
January, 2004	Commissioning

Astrid Jürgensen and Yongfeng Hu working with the gas phase time-of-flight mass spectrometer at the CSRF spherical grating monochromator beamline currently operating at the SRC in Madison, WI. This instrumentation will be used at the CLS.