Five Mirrors for the Spherical Grating Monochromator (SGM) and Variable Line Spaced Plane Grating Monochromator (VLS-PGM) Beamlines

6.8.80.3 Rev.0

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REVISION HISTORY

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A	02-May-14	Original Draft	Ian Coulthard
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1.0 INTRODUCTION

1.1 PURPOSE

This document specifies the requirements for 5 mirrors to be fabricated, and installed on the floor at the Canadian Light Source (CLS). These components will be part of the variable line spacing plane grating monochromator (VLS-PGM) and spherical grating monochromator (SGM) beamlines.

1.2 SCOPE

The VLS-PGM and SGM beamlines as specified by the user community require high resolution and flux combined with a reasonably small beam size at the sample. The insertion devices for these two lines are to be placed in the same straight section of the CLS ring. As a result, vacuum chambers in the first optical enclosure (FOE) will largely be shared by both lines. This specification details the requirements for the fabrication, supply, and delivery of 5 beamline mirrors to be placed in the vacuum chambers of this common FOE area. This specification includes but is not limited to:

- 3 plane mirrors
- 1 toroidal mirror
- 1cylindrical mirror
- fabrication, handling, and shipping guidelines
- delivery at CLS
- quality assurance and safety

1.3 BACKGROUND

The Canadian Light Source is a national facility under construction on the University of Saskatchewan campus in Saskatoon, Saskatchewan. This facility is a 3rd generation synchrotron light (SR) source, which will produce a high intensity source of infrared, ultraviolet and x-ray radiation.

SpectroMicroscopy Beamline (SM) is a soft x-ray microscopy desiccated facility, which will provide intense soft x-ray light for Scanning Transmission X-ray Microscope and Photoelectron Emission Microscope. It will be built in the 10ID sector of the CLS main ring.

M3 PEEM mirror is the forth optical element of the SM beamline. It is placed ~22.6m away from an Elliptically Polarized Undulator (EPU) and reflects the synchrotron radiation (SR) beam horizontally by 3 degree inboard (to the right as seen along the photon beam). The design of the mirror vacuum vessel allows to retract it to clear the optical path for M3 mirror of the STXM. The mirror orientation is vertical. The mirror has a toroidal shape of the optical surface, with the major radius plane (tangential plane) oriented horizontally. The sagittal (minor) radius is chosen so that the SR, dispersed by Plane Grating Monochromator (PGM) and collimated in vertical direction is focused on the exit slit 3 m downstream of the mirror. The tangential (major) radius is choused to provide a focusing condition in horizontal plane, so the electron beam, which is the source in this case, will be projected to the same exit slit.

The power load absorbed by the mirror out of the EPU may be up to 10W, if the PGM is operated in zero order. Such power load does not required the internal water cooled design, but a moderate heat sink. So, the mirror is design as a monolithic block with cooling copper plate attached from below.

For alignment purpose the upper side of the mirror has a mirror-lake polished surface, parallel to the mirror central axis. The size and location of this surface is defined in the attached drawing package.

The main optical surface area is 370 mm long by 20 mm wide. Surface figure errors and micro-roughness should not exceed the specified tolerances. The optical surface of the mirror shall be gold coated.

The mirror must be capable of being operated in an ultra high vacuum environment and subjected to soft x-ray radiation. It should withstand baking to 200^{o}C for 24 hours, and retain its shape and performance characteristic upon cooling to room temperature. The maximum operating temperature at the mirror surface is not to exceeded 30^{o}C.

Further background information can be found in the SM Preliminary Design Review CLS #6.2.76.10.

2.0 GENERAL DESCRIPTION OF OPTICS

This section shall define and give a general description of the five beamline optical components covered in this specification.

2.1 REFERENCE DOCUMENTS AND TABLES

Refer to the following supplied documents and drawings to aid in the definition of each optical component requiring fabrication. Please note that these supplied documents and tables also list components not covered in this specification. The specification covers specifically the M1 and M2 mirrors of the VLS-PGM line, and the M1, M2, and M3 mirrors of the SGM line. Please note in the preliminary SGM report, the M3 cylindrical focusing mirror is actually referred to as M2 and all numbers in this specification should be considered correct. Certain sections of these documents deemed not necessary for this specification or deemed of a sensitive nature may have been removed.

(a) Ruben Reininger, "Technical Preliminary Design Report For the Variable Line Spacing-Plane Grating Monochromator (VLS-PGM) Beamline for the Canadian Light Source", July 16, 2001. [1].

(b) Ian Coulthard, "Technical Preliminary Design Report For the Madison Spherical Grating Monochromator (SGM) Beamline to be Modified for the Canadian Light Source", May 31, 2001. [2].

2.2 PGM M1

This plane mirror with a grazing angle of incidence of 1.5 degrees acts largely as a power filter for the VLS-PGM line, and also serves to further separate the beam from the two insertion devices.

2.3 PGM M2

This toroidal mirror with a grazing angle of incidence of 4.5 degrees focuses the beam vertically and collimates the beam horizontally.

2.4 SGM M1

This plane mirror with a grazing angle of incidence of 0.75 degrees serves as the main power filter for the SGM line.

2.5 SGM M2

This plane mirror with a grazing angle of incidence of 0.75 degrees further deflects the SGM beam horizontally.

2.6 SGM M3

This cylindrical mirror with a grazing angle of incidence of 1 degree deflects the beam downward and focuses the beam vertically upon the SGM entrance slit.

3.0 GLOBAL REQUIREMENTS

3.1 All fabrication of these optical components shall be consistent with operation of these components in ultra-high vacuum (UHV) conditions.

3.2 Detailed design and construction of the vacuum chambers, including the mounts, holders, cooling, and movement mechanisms for mirrors is to be undertaken by a different proponent, under a different specification.

3.3 Finite element analysis (FEA) is being performed on all five optical components mirrors. This analysis when completed by Instrument Design Technology Ltd., shall be incorporated into the detailed designed of the mounts and cooling for these optics.

3.4 All non-optical surfaces must be ground to within 0.025 mm.

3.5 Unless otherwise shown below, all substrate dimensions should have a tolerance of plus or minus 0.3 mm.

3.6 Machining on the sides of all substrates shall conform to the conceptual diagram for machining required to mate substrate to optical mounts [7]. In each case this machining consists of two steps/ledges, one along each side of the long axis of the substrate at the base. This step shall be 10 mm in height and 10 mm in width.

3.7 All widths/heights of substrates as specified in the document shall refer to the width/height of the optic at the optical surface and NOT the width/height at the base of the substrate where the steps/ledges are found.

4.0 PGM M1 REQUIREMENTS

4.1 The mirror figure shall be planar

4.2 The grazing angle of incidence for this mirror shall be 1.5 degrees.

4.3 The mirror substrate shall be Si.

4.4 The reflective surface of this mirror shall be graphite. The graphite shall be of sufficient thickness for the mirror to act almost completely with respect to the photon beam as if the entire mirror was graphite.

4.5 The length of this mirror shall be 400 mm.

4.6 The height of this mirror shall be 40 mm.

4.7 The substrate thickness shall be 50 mm.

4.8 The Tangential figure error shall be 2.0 arcsec or better.

4.9 The Sagittal figure error shall be 1 arcsec or better.

4.10 Surface roughness of the mirror shall be 1.5 nm or better.

5.0 PGM M2 REQUIREMENTS

5.1 The mirror figure shall be toroidal with a Tangential radius of 422.4 m to within 1% or better, and a Sagittal radius of 0.520 m to within 1% or better.

5.2 The grazing angle of incidence for this mirror shall be 4.5 degrees.

5.3 The mirror substrate shall be Si.

5.4 The reflective surface of this mirror shall be graphite. The graphite shall be of sufficient thickness for the mirror to act almost completely with respect to the photon beam as if the entire mirror was graphite.

5.5 The length of this mirror shall be 200 mm.

5.6 The height of this mirror shall be 40 mm.

5.7 The substrate thickness shall be 50 mm.

5.8 The Tangential figure error shall be 2.0 arcsec or better.

5.9 The Sagittal figure error shall be 1.5 arcsec or better.

5.10 Surface roughness of the mirror shall be 0.5 nm or better.

6.0 SGM M1 REQUIREMENTS

6.1 The mirror figure shall be planar

6.2 The grazing angle of incidence for this mirror shall be 0.75 degrees.

6.3 The mirror substrate shall be Si.

6.4 The reflective surfaces of this mirror shall be Si and graphite. Transition between these two reflective stripes shall be accomplished via a vertical translation of the mirror. The stripes shall each cover one half of the mirror surface and the mid-point between stripes shall be centered on the mirror.

6.5 The length of this mirror shall be 400 mm.

6.6 The height of this mirror shall be 40 mm.

6.7 The substrate thickness shall be 50 mm.

6.8 The Tangential figure error shall be 2.0 arcsec or better.

6.9 The Sagittal figure error shall be 1 arcsec or better.

6.10 Surface roughness of the mirror shall be 1.5 nm or better.

7.0 SGM M2 REQUIREMENTS

7.1 The mirror figure shall be planar.

7.2 The grazing angle of incidence for this mirror shall be 0.75 degrees.

7.3 The mirror substrate shall be Si.

7.4 The reflective surfac es of this mirror shall be Si and graphite. Transition between these two reflective stripes shall be accomplished via a vertical translation of the mirror. The stripes shall each cover one half of the mirror surface and the mid-point between stripes shall be centered on the mirror.

7.5 The length of this mirror substrate shall be 400 mm.

7.6 The height of this grating shall be 40 mm.

7.7 The substrate thickness shall be 50 mm.

7.8 The Tangential figure error shall be 2.0 arcsec or better.

7.9 The Sagittal figure error shall be 1.0 arcsec or better.

7.10 Surface roughness of the mirror shall be 1.5 nm or better.

8.0 SGM M3 REQUIREMENTS

8.1 The mirror figure shall be cylindrical along the tangential length such as to vertically focus the beam with a radius of 223.986 m to within 1% or better.

8.2 The grazing angle of incidence for this mirror shall be 1 degree.

8.3 The grating substrate shall be Si.

8.4 The reflective surfaces of this mirror shall be Si and Rh. Transition between these two reflective stripes shall be accomplished via a horizontal translation of the mirror.

8.5 The length of this mirror shall be 150 mm.

8.6 The width of this mirror shall be 40 mm.

8.7 The substrate thickness shall be 50 mm.

8.8 The Tangential figure error shall be between 0.5 and 0.7 arcsec.

8.9 The Sagittal figure error shall be 1 arcsec or better.

8.10 Surface roughness of the mirror shall be 1.5 nm or better.

9.0 SAFETY, ENVIRONMENTAL, AND RELIABILITY

9.1 The vacuum chambers shall be capable of operation in an ambient temperature range of 10 to 40 degrees C. The normal ambient temperature on the experimental floor is 21 degrees C. The expected temperature stability of the building will be 1 degree C during normal operation.

9.2 The components shall be able to withstand a relative humidity range of 0% to 95%. The expected relative humidity limits under operation are from 25% during the winter months and a maximum of 50% during the summer months. The expected relative humidity range for components under storage will be the same as previously mentioned.

10.0 QUALITY ASSURANCE AND TESTING

10.1 The proponent shall maintain and apply a quality assurance program compliant with ISO-9001 for the design, manufacture, procurement, testing and installation of all four sections.

11.0 APPLICABLE CODES, STANDARDS, AND PROCEDURES

This work shall meet the following standards. The issue of any standard shall be the issue in effect as of the date of request for tender. Any conflicts between this specification and the referenced documents shall be brought to the attention of the CLS in writing for resolution before any related action is to be taken by the proponent.

American Welding Society (AWS)

- American Society for Testing and Material (ASTM)
- American Society of Mechanical Engineers, Boiler and Pressure Vessel Code
- (ASME-BPVC)
- American National Standards Institute (ANSI)
- International Standards Organization (ISO)
- Canadian Light Source Vacuum Component Cleaning Technical Procedure [3]
- Canadian Light Source Vacuum Component Leak Test Technical Procedure [4]

12.0 OTHER REQUIREMENTS

12.1 All components of each section shall be completed, and delivered to the CLS as soon as possible. The proponent shall deliver a list of expected completion dates for each optical component.

12.2 Packaging to be used during shipping of components shall ensure protection of the components from water, dust, oil, and vibration during shipping. The packaging should be hermetically sealed

12.3 Components shall be held securely in the shipping containers to prevent chafing or scratching that could damage the components and / or generate contaminants.

12.4 Vacuum chambers should be shipped under pressure with dry nitrogen gas.

12.5 The shipping containers shall be properly labeled in English to ensure proper care during shipment.

12.6 All documentation to the CLS shall be in English [6].

12.7 Documentation supplied to the CLS shall be provided in hard copy in triplicate plus one electronic copy if available. All drawings shall be supplied in AutoCAD format. All drawings and other documentation should also be appropriately labeled, numbered, and include a revision history.

12.8 Documentation detailing the proper handling, and cleaning of these components shall be included.

13.0 REFERENCES

1. Ruben Reininger, "Technical Preliminary Design Report For the Variable Line Spacing-Plane Grating Monochromator (VLS-PGM) Beamline for the Canadian Light Source, July 16, 2001.
2. Ian Coulthard, "Technical Preliminary Design Report For the Madison Spherical Grating Monochromator (SGM) Beamline to be Modified for the Canadian Light Source", May 31,

2001.

3. **Canadian Light Source Vacuum Component Cleaning Technical Procedure, 8.7.33.1, September 13, 2000.**
4. **Canadian Light Source Vacuum Component Leak Test Technical Procedure, 8.7.33.2, September 13, 2000.**
5. D.S. Lowe. "CLS Document Specification", 0.4.1.1 Rev. 2 14 Dec 2000.
6. Concept drawing of standard substrate shape including base steps/ledges for mating substrates to mirror mounts.

RFP Selection Criteria

(a) Technical — 35%

- understanding the scope of the work
- -fabrication, assembly, installation plan
- -ability to meet minimum functional and performance requirements
- -performance ability
- -quality and duration of proposed warranty periods
- -proposed delivery if different from stated

(b) Cost — 35%

- proposal pricing
- -cost saving proposals
- -value added benefits and incentives
- -proposed payment structure

(c) Proponent Qualifications — 20%

- -corporation structure and ownership
- -demonstrated ability to satisfy the University requirements
- -relevant experience, competence, and reliability in handling similar projects, based upon references
- -international scientific reputation of company

(d) Economic Benefits and Incentives Program — 5%

- national, regional, and local benefits

(e) Any other factors the CLS may consider appropriate — 5%

100 %

Note: All bids are to be submitted in Canadian dollars.

Scope of Work

The Proponent shall provide all material, labour, equipment, and services required to complete the Work as set out in the RFP. The Work shall be that which is called for in specifications and drawings. The Work shall include but is not limited to the following:

1. Supply and complete the planning, design, and engineering to carry out the Work.
2. Plan and implement the procurement of materials, equipment, and services to carry out the work.
3. Provide and implement a Quality Assurance and Control Program (QA/QC) for the Work. The QA/QC program to include the testing, certifications, and inspections specified within this RFP.
4. Carry out, document, and distribute the results of testing, certifications, and inspections as specified within this RFP.
5. Provide documentation as specified within this RFP.
6. Provide the components specified in this document including all five optical elements.
7. Provide all measurement and testing as defined or required to perform the work. Provide copies of all results to the CLS.
8. Provide packaging and transportation of finished product to designated CLS site.

Proposal Cost Summary Form

Proponents shall provide their proposal cost summary using the following format in Canadian dollars:

Five Mirrors for the Spherical Grating Monochromator (SGM) and Variable Line Spacing Plane Grating Monochromator (VLS-PGM) Beamlines

Items #	Description	Quantity	Unit Rate	Total
1	Fabrication PGM M1	1		
2	Fabrication PGM M1	1		
3	Fabrication SGM M1	1		
4	Fabrication SGM M2	1		
5	Fabrication SGM M3	1		
6	Factory Testing	1		
7	Subtotal			
8	PST			
9	GST			
10	Duties			
11	Shipping			
12	Subtotal			
13	Total			

Special Requirements to be Included in RFP

1. Proponent shall provide examples of previous work that demonstrates the proponent's capacity to fabricate beamline components with similar performance to the components specified in this document.
2. Provide names and phone numbers of two references to whom the proponent has supplied synchrotron beamline components to that may be contacted by the CLS.
3. Proponent shall provide a list of any exceptions or alterations to statements, parameters, and tolerances in this document and attached drawings.
4. CLS reserves the right to visit the proponent's facility before awarding a contract.
5. CLS reserves the right to inspect components and facilities during fabrication.
6. The proponent shall propose a schedule with the following milestones:
   - start
   - completion of substrates
   - completion of optical figures
   - completion of mirrors
   - completion of grating ruling
   - factory tests
   - shipment to CLS

The proponent shall also propose a schedule of site visits by representatives of the CLS. It is suggested that these visits occur at approximately the following milestones

   - factory tests
   - -just before shipment to the CLS

7. All parameters of the optics specified in this document, including but not necessarily limited to: figure errors, and surface roughness, shall be measured and submitted to CLS prior to final approval of any optic. The methods used to measure these parameters shall be described in the bid statement.