Three Reflective and Two Crystal Optics for the CLS Soft X-Ray Micro-characterization Beamline (SXRMB)

29.8.36.1 Rev.0

Date: 13 December 2005

Canadian Light Source Inc.
101 Perimeter Road
University of Saskatchewan
Saskatoon, Saskatchewan Canada

	Signature	Date
	Original on File – Signed by:	
Author	Ian Coulthard	
Reviewer #1	Curtis Mullin	
Reviewer #2	Jeff Cutler	
Reviewer #3	Brian Yates	
Approver	Emil Hallin	

BLANK PAGE

REVISION HISTORY

Revision	*Date*	*Description*	*Author*
A	29 November 2005	Original Draft	Ian Coulthard
0	13 December 2005	Issued for use	Ian Coulthard

BLANK PAGE

TABLE OF CONTENTS

BLANK PAGE

1. INTRODUCTION

1.1 PURPOSE

This document specifies the requirements for 5 optics (3 reflective, 2 crystal) to be fabricated for the Canadian Light Source (CLS). These components will be part of the Soft X-Ray Micro-characterization Beamline (SXRMB).

1.2 SCOPE

The SXRM beamline as specified by the user community requires high flux for spectroscopy coupled with microprobe ability for imaging. This specification details the requirements for the fabrication, supply, and delivery of 5 beamline optics to be placed in the vacuum chambers of this beamline. This specification includes but is not limited to:

- 1 plane mirror,
- 1 toroidal mirror,
- 1 cylindrical mirror,
- 2 pairs of crystal optics,
- fabrication guidelines, and
- quality assurance.

1.3 BACKGROUND

The Canadian Light Source is a national facility under operation at the University of Saskatchewan campus in Saskatoon, Saskatchewan. This facility is a third generation synchrotron light source that produces a high intensity source of infrared, visible, ultraviolet, and x-ray radiation. Based upon the needs of the Canadian synchrotron community, the SXRM beamline with a double crystal monochromator and energy range of 1.7 – 10 keV is being constructed with a goal of being ready for commissioning in early 2007.

2 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

CLS Document 29.2.1.2 Rev 0 CLS 06-BM-1 SXRMB Preliminary Design Report aids in the definition of each optical component requiring fabrication. Please note that CLS Document 29.2.1.2 also lists components not covered in this specification. Certain sections of CLS Document 29.2.1.2 deemed not necessary for this specification or deemed of a sensitive nature may have been removed.

This Specification defines the pre and post-monochromator reflective optics, and the monochromator crystal optics only.

2.2 VERTICAL COLLIMATING MIRROR

This plane mirror bent into a cylinder with a grazing angle of incidence of 0.45 degrees acts largely as a power and harmonic filter for the beamline and vertically collimates the beam entering the monochromator.

2.3 InSb (111) CRYSTALS

These crystals are utilized to cover the lower energy range of the beamline.

2.4 Si (111) CRYSTALS

These crystals are utilized to cover the higher energy range of the beamline.

2.5 POST-MONOCHROMATOR TOROID

This toroidal mirror with a grazing angle of incidence of 0.45 degrees focuses the beam for the XAFS/Spectroscopy endstation area.

2.6 POST-MONOCHROMATOR SAGITTAL CYLINDER

This cylindrical mirror with a grazing angle of incidence of 0.45 degree collimates the beam horizontally that is sent to the microprobe endstation area.

3 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 The detailed design of the vacuum chambers, including the mounts, holders, cooling, and movement mechanisms for the optics is not defined in this specification.

3.3 Finite element analysis (FEA) is being performed at the CLS on the InSb (111) first crystal. The results shall be incorporated into the cooling and temperature equilibration strategy for the crystal 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 The dimensions of the substrate for each optic shall be referred to in the specification as “absolute” dimensions. The required dimensions of any and all reflective coatings shall be specified separately.

3.7 For reflective optics, Fizeau interferometry, long trace profilometry, interferometric microscopy shall be used to verify that specifications have been met. Results of these tests shall be submitted to the CLS for review before final approval of any optic is given.

3.8 Surface roughness microscopy measurements shall be conducted with 5X and 20X objective lenses. The Proponent shall specify the camera resolution to be used.

3.9 The locations on mirror surfaces for measuring slope error and surface roughness shall be determined in consultation with CLSI.

3.10 For crystal optics, the following techniques shall be used to verify that specifications have been met:

- Laue diffraction pattern,
- rocking curve analysis,
- topographic analysis.

Results of these tests shall be submitted to the CLS for review before final approval of any optic is given.

4 VERTICAL COLLIMATING MIRROR REQUIREMENTS

4.1 The mirror figure shall be planar (R > 2 * 105 m). Note: This mirror shall be dynamically bent into a longitudinal cylinder of radius 3.5651 km.

4.2 The grazing angle of incidence for this mirror shall be 0.45 degrees.

4.3 The mirror substrate shall be Si.

4.4 The absolute length of this mirror shall be 1000 mm.

4.5 The absolute width of this mirror shall be 80 mm.

4.6 The absolute substrate thickness shall be 100 mm.

4.7 The RMS Tangential figure error shall be 2.0 microradians or better.

4.8 The RMS Sagittal figure error shall be 4 microradians or better.

4.9 RMS surface roughness of the mirror shall be 0.5 nm or better prior to coating.

4.10 RMS surface roughness of the mirror shall be 1.0 nm or better after coating.

4.11 The mirror shall have reflective coatings of diamond like carbon (DLC density > 2.2 gr/cm^3), and platinum. What about the double layer?

4.12 Each mirror coating shall have a width of 25 mm with a 10 mm buffer area between each coating.

4.13 Each mirror coating shall have a length of 900 mm.

4.14 Each mirror coating shall have a thickness of 30 nm.

5 INSB (111) CRYSTAL REQUIREMENTS

5.1 The crystals shall be made of InSb.

5.2 The beam direction shall be (111) plus or minus 0.01 degrees.

5.3 Orientation accuracy shall be plus or minus 0.01 degrees.

5.4 Diffracting surfaces are to be lapped, polished, and etched to give a FWHM rocking curve to within 1 ArcSec of the theoretical value.

5.5 All diffracting surfaces are to be free of strain after lapping, polishing, and etching.

5.6 The width of both crystals shall be 25 mm.

5.7 The thickness of both crystals shall be 1 mm plus or minus 0.01 mm.

5.8 The length of the first crystals shall be 40mm. The length of the second crystal shall be 50 mm.

5.9 Diffracting surface flatness shall be better than 10 microradians RMS.

5.10 Diffracting surface roughness shall be better than 1 nm RMS.

6 SI (111) CRYSTALS REQUIREMENTS

6.1 The crystals shall be made of high resistivity float zone Si.

6.2 The beam direction shall be (111) plus or minus 0.01 degrees.

6.3 Orientation accuracy shall be plus or minus 0.01 degrees.

6.4 Diffracting surfaces are to be lapped, polished, and etched to give a FWHM rocking curve to within 0.2 ArcSec of the theoretical value.

6.5 All diffracting surfaces are to be free of strain after lapping, polishing, and etching.

6.6 The width of both crystals shall be 25 mm.

6.7 The thickness of both crystals shall be 5 mm plus or minus 0.01 mm.

6.8 The length of the first crystals shall be 40mm. The length of the second crystal shall be 50 mm.

6.9 Diffracting surface flatness shall be better than 10 microradians RMS.

6.10 Diffracting surface roughness shall be better than 1 nm RMS.

7 POST-MONOCHROMATOR TOROID REQUIREMENTS

7.1 The mirror figure shall be toroidal.

7.2 The grazing angle of incidence for this mirror shall be 0.45 degrees.

7.3 The mirror substrate shall be Si.

7.4 The absolute length of this mirror shall be 1000 mm.

7.5 The absolute width of this mirror shall be 50 mm.

7.6 The absolute substrate thickness shall be 100 mm.

7.7 The tangential curvature shall be 2.8011 km plus or minus 1%.

7.8 The Sagittal curvature shall be 107.25 mm plus or minus 1%.

7.9 RMS tangential figure error shall be 2 microradians or better.

7.10 RMS Sagittal figure error shall be 4 microradians or better.

7.11 RMS surface roughness of the mirror shall be 0.5 nm or better prior to coating.

7.12 RMS surface roughness of the mirror shall be 1.0 nm or better after coating.

7.13 The mirror shall have a bi-layer reflective coating composed of 10 nm of DLC (density > 2.2 gr/cm^3) on top of 30 nm of platinum.

7.14 The mirror coating shall have a length of 900 mm.

8 POST-MONOCHROMATOR SAGITTAL CYLINDER REQUIREMENTS

8.1 The mirror figure shall be cylindrical in the Sagittal direction.

8.2 The grazing angle of incidence for this mirror shall be 0.45 degrees.

8.3 The mirror substrate shall be Si.

8.4 The absolute length of this mirror shall be 550 mm.

8.5 The absolute width of this mirror shall be 40 mm.

8.6 The absolute substrate thickness shall be 100 mm.

8.7 The Sagittal curvature shall be 282.74 mm plus or minus 1%.

8.8 RMS tangential figure error shall be 2 microradians or better.

8.9 RMS Sagittal figure error shall be 4 microradians or better.

8.10 RMS surface roughness of the mirror shall be 0.5 nm or better prior to coating.

8.11 RMS surface roughness of the mirror shall be 1.0 nm or better after coating.

8.12 The mirror shall have a bi-layer reflective coating composed of 10 nm of DLC (density > 2.2 gr/cm^3) on top of 30 nm of platinum.

8.13 The mirror coating shall have a length of 450 mm.

9 ENVIRONMENTAL

9.1 The vacuum chambers that will house the optics 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 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[2]
- Canadian Light Source Vacuum Component Leak Test Technical Procedure[3]

11 REFERENCES

- Canadian Light Source Document 29.2.1.2 Rev 0 CLS 06-BM-1 SXRMB Preliminary Design Report
- Canadian Light Source Document 8.7.33.1 Rev 1Vacuum Component Cleaning Technical Procedure
- Canadian Light Source Document 8.7.33.2 Rev 1 Vacuum Component Leak Test Technical Procedure
- Canadian Light Source Document 0.4.1.1 Rev.3 Vendor Documentation Specification.