

CMCF 08ID-1 Technical Specifications for the Vertical Focusing Mirror Substrate

Technical Specification 6.8.77.2 Rev. 0

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1.0 INTRODUCTION

1.1 PURPOSE

This document contains the technical specifications for the vertical mirror substrate for the CMCF 08ID-1 beamline at the Canadian Light Source.

1.2 SCOPE

This technical specification establishes the requirements for the fabrication, inspection, testing and delivery of the substrate for a focusable x-ray mirror substrate.

1.3 BACKGROUND

The mirror substrate will be used to reflect and focus x-rays of energies between 6.0 20.0 keV generated by the in-vacuum small gap undulator. The mirror substrate surface figure is to be manufactured as a plane. The mirror substrate will be mounted in a bending mechanism that generates the cylindrical surface figure required for the focusing applications. Surface figure errors and micro-roughness not exceeding the tolerances listed and meeting the requirements in Section 2.2.1 and 2.2.2 are essential for successful application of the mirror substrate. One third of the substrate surface shall be coated with Palladium; one-third with Platinum and the remaining surface shall remain uncoated. The mirror substrate must be capable of being operated in high vacuum (better than 10^{-6} Pa) environment and subjected to hard x-ray radiation.

1.4 DEFINITIONS AND ABBREVIATIONS

rms - root mean square

SGU – small-gap undulator

Zerodur[®] is a registered trademark glass ceramic of Schott Glaswerke, Mainz.

ULE is a registered trademark glass ceramic of Corning. The other material names specified on the drawing denote chemical elements.

2.0 REQUIREMENTS

2.1 FUNCTION

The following drawing specifies the mirror substrate that is to be fabricated by the Bidder. The drawing is attached to this technical specification.

Drawing: 08ID-1/ME/MIR/0055450.

The bidder shall fabricate the mirror substrate to the specifications given in this document and CLS drawing 08ID-1/ME/MIR/0055450. Material names, other than trademark names on 08ID-1/ME/MIR/0055450 denote chemical elements

2.2 PERFORMANCE

2.2.1 Surface roughness

Surface roughness shall be defined as the root mean square (rms) of the surface amplitudes with spatial wavelengths between 5 μm and 2 mm. **The average surface roughness shall not exceed 2.0 \AA rms** when measured with a 5X objective and 2.5 \AA when measured with a 40X objective. The surface roughness shall not exceed 2.8 \AA rms at any location when measured with 5X objective or 3.3 \AA rms when measured with a 40X objective.

2.2.1.1 Measurements of the surface roughness

1. The surface roughness of the mirror substrate shall be measured with a non-contacting optical profiler using phase measuring interferometer technique. The instrument shall have objectives of approximately 5X and 40X magnification, capable of 20 μm and 5 μm camera resolution, respectively, and have at least 0.2 nm height resolution. Acceptable are instruments manufactured by Wyko, Zygo, and Micromap. Alternates must be approved by the CLS.
2. The surface roughness shall be measured at the following locations (minimum requirement): (a) eleven test spots per stripe of coated or uncoated stripe, located along the center line, spaced 100 mm apart starting from the middle of active area and (b) two test spots located on the mid-line (parallel to the 100 mm edge).
3. Surface roughness shall be measured two dimensionally as the root mean square of all surface height deviations from the average height measured in a rectangular sample area of size specified below at a certain step size specified below. If a two-dimensional evaluation algorithm is not available, it is determined as the average of the rms height variation of at least 5 profiles, covering the specified size of the sampling area, in a direction parallel to the long dimension of the mirror and at least 5 profiles orthogonal to this direction.
4. The surface roughness shall be determined at two different magnifications, camera resolution, and sampling sizes: (a) with 5X objective, 20 μm camera resolution and a sampling area of 2 to 3 mm by 2 to 3 mm and (b) with 40X objective, 5 μm camera resolution and a sampling area of size 0.25 to 0.35 mm by 0.25 to 0.35 mm.

2.2.2 Slope error

Slope error shall be defined as the root mean square of the slope of the mirror surface with spatial wavelengths between 2 mm and 1000 mm. **The average slope error shall**

not exceed 1.0 μ rad rms for any stripe (areas marked A2, A3, and A4 on the drawing 08ID-1/ME/MIR/0055450). The slope error measured and calculated shall not exceed 1.5 μ rad rms at any of the locations. The slope error measured in the direction of the short side (100 mm) of the mirror shall not exceed 25 μ rad.

2.2.2.1 Measurements of the surface figure slope error

1. The surface figure of the finished mirror substrate shall be measured with a long trace profiler. Acceptable are instruments manufactured by Ocean Optics, Inc. Alternates must be approved by the CLS.
2. Three profile traces of 1000 mm length shall be measured for each stripe of coating or the uncoated stripe, respectively. One trace shall be along the centerline of each stripe, and one trace each at a distance of 10 mm to either side of the centerline of each stripe. The step size or camera resolution shall be 1 mm.
3. The orientation of the mirror substrate during measurement of profile traces shall be specified. Deformation of the mirror due to gravity shall be calculated and subtracted before slope error is evaluated. Formulae used must be included in Bidder's Inspection and Test Plan.
4. For each coated or uncoated stripe (areas marked A2, A3 and A4 in the drawing 08ID-1/ME/MIR/0055450) a common linear component of the slope error of the mirror surface, not exceeding 5×10^{-8} rad/mm, may be subtracted before determining the residual slope errors. In terms of surface figure, this corresponds to subtracting from the measured surface figure of a stripe a cylindrical component (cylinder axis in direction of short side of surface –A-) of a radius curvature greater than 20,000 m.

The slope error is acceptable if: (a) none of the average of the root mean square (rms) of the slope errors determined separately for each coated or uncoated stripe (areas marked A2, A3 and A4 in the drawing 08ID-1/ME/MIR/0055450) in the manner specified above exceeds 1.0 μ rad, and (b) none of the individual rms slope errors exceeds 1.5 μ rad, and (c) the slope error measured in the direction of the short side of the surface – A- does not exceed 25 μ rad.

2.2.3 Material requirements

The Bidder shall use the materials specified in the drawing, which is listed in Section 2.2 of this Technical Specifications, and certification of materials used in the fabrication shall be submitted to the CLS at the time of delivery.

All materials shall be capable of withstanding 200°C bakeout for 24 hours and hard x-radiation environment with photon energies between 3 and 100 keV.

2.2.3.1 Silicon

Silicon shall be single crystal (optical grade). Bidder shall include in its proposal the dislocation density of the material he is proposing to be used.

2.2.3.2 Palladium

The palladium material used for coating shall be > 99.99% pure.

2.2.3.3 Platinum

The platinum material used for coating shall be > 99.99% pure. Total impurities of elements with Z>22 shall be less than 50 ppm.

2.2.4 Other requirements

2.2.4.1 Machining

2.2.4.1.1 The mirror substrate shall be machined in accordance with common industrial procedures applicable to the selected substrate material. The machining process used shall be compatible with UHV applications.

2.2.4.1.2 No silicone or sulfur-based cutting fluids shall be used.

2.2.4.1.3 No operation causing contaminants to be embedded into the mirror substrate surface shall be permitted.

2.2.4.2 Coating

The Bidder shall coat active surface of the mirror substrate as specified in the drawing 08ID-1/ME/MIR/0055450. Any additional coatings (e.g. adherence layer) deemed necessary should be specified and submitted to CLS for review and acceptance prior to fabrication.

2.2.4.3 Identification

The mirror shall have an arrow pointing to the active surface engraved into the side face at the location indicated in Drawing 08ID-1/ME/MIR/0055450. Next to the arrow, the mirror shall have an identifying letter plus number combination of type Gxx engraved into the side face at the location indicated in the Drawing. The one or two digit number will be issued by the CLS at the time of contract award.

2.2.4.4 Polishing

The active surfaces of the mirror substrate in the drawing 08ID-1/ME/MIR/0055450 shall be polished as specified.

The bidder shall provide in his proposal documentation of polishing hardware and the polishing protocol he intends to use for mirror substrate described in this Technical Specification. The documentation shall include the following information: (a) diameter of polishing wheel (or equivalent device); (b) type of motion of the mirror substrate during polishing; and (c) mechanical arrangement or procedure by which the motion of the mirror substrate is generated.

The slope error and surface roughness of finished mirror after coating, as applicable, that must not be exceeded are specified in Section 2.2.1.1 and 2.2.2.1, respectively.

2.2.4.5 Cleaning

2.2.4.5.1 The mirror must be clean before applying the coatings.

2.2.4.5.2 The finished mirror must be clean and ready for use in UHV.

2.2.4.5.3 Residual materials that are not compatible with UHV environment shall not be present. UHV requirements are for low outgassing rates on the order of 10^{-7} Pa·liter/sec·mm² (10^{11} Torr·liter/ sec·cm²) and no detectable hydrocarbon.

2.2.4.5.4 The bidder shall provide the CLS with its proposal a summary of the cleaning procedures to be used on the mirror in order to remove all of the polishing material

2.2.4.6 Workmanship, handling

- The parts shall be free of dents, gouges and scratches.
- Lint-free and talcum-free nylon gloves shall be worn when handling the mirror substrate after cleaning.
- No fingerprints are permitted.

2.2.4.7 Drawing corrections

As-built drawing shall be provided to CLS.

2.3 QUALITY ASSURANCE

The following examination requirements shall comprise the minimum acceptable for the mirror substrate.

All certifications of materials, test processes, calibration of test equipment and test data shall be signed by the Bidder representative authorized to sign such certification. A copy of the original test data shall be provided to the CLS.

2.3.1 Fabrication examination

2.3.1.1 *General*

All items shall be subjected to visual and dimensional examination to verify conformance with drawing requirements.

2.3.1.2 *Final dimensions*

Bidder shall report to the CLS the exact final dimensions of the substrate six (6) weeks before delivery.