SUBSTRATE, ALIGO SIGNAL RECYCLING MIRROR (SRM) for L1 and H1 interferometers -unfolded

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Applicable Documents

LIGO-D0901174-v4	Signal Recycling Mirror Substrate
LIGO-D080038-B	ALIGO Recycling Mirror 1 Blank
LIGO-E080028-A	Mirror Blank Material, AdLIGO Recycling Mirror 1 (RM1)

Requirements

Physical Configuration

According to LIGO-D0901174-v4 Signal Recycling Mirror Substrate

Fabricate from

LIGO-D080038-B	ALIGO Recycling Mirror 1 Blank
LIGO-E080028-A	Mirror Blank Material, AdLIGO Recycling Mirror 1 (RM1)

Registration Marks

Registration marks shall be etched, ground or sandblasted and located per LIGO-D0901174-v4.

Arrow indicates Surface 1, the highly reflective surface.

Serial Number

Serial Number "SRM-XX" shall be etched, ground or sandblasted on the barrel of the optic per LIGO-D0901174-v4, where X is incremental starting with 01.

Surface, Side and Bevel Polish

All Surfaces, Sides and Bevels shall be polished using a progression of smaller grit sizes. The last step before final polish shall be equal to or less than a five micrometer grit finish. These surfaces shall appear transparent with no grey, scuffs or scratches visible to the naked eye when viewed in normal room light against a black background.

Bevel

Bevel for safety per LIGO-D0901174-v4

Wedge angle

Specified according to drawing LIGO-D0901174-v4 Signal Recycling Mirror Substrate

Witness Samples:

Vendor will deliver two 2-inch witness samples according to requirements on page 4 of this specification.

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Scratches, Sleeks and Point defects

Point defects of radius greater than 25 micrometers are treated like scratches for the purpose of this specification.

Scratches and Sleeks, Surface 1
There shall be no scratches and sleeks within the central 15 mm diameter.

The total area of scratches and sleeks within the central 30 mm diameter shall not exceed 400 square micrometers (width times length.)

The total area of scratches and sleeks outside the central 30 mm diameter shall not exceed 23×10^4 square micrometers.

Point Defects, Surface 1
There shall be no point defects of radius greater than 2 micrometers within central 15 mm.

There shall be no more than 1 point defect of radius greater than 2 micrometers within the central 30 mm diameter.

Average density of defects less than 2 micrometers radius within the central 30 mm diameter must be less than or equal with 1 per 4 mm^2.

The maximum concentration of localized defects over the central 30 mm diameter shall be no more than 30 square micrometers per 1 mm diameter.

Scratches and Sleeks, Surface 2
The total area of scratches and sleeks within the central 15 mm diameter shall not exceed 400 square micrometers (width times length).

The total area of scratches and sleeks within the central 30 mm diameter shall not exceed 53×10^2 square micrometers.

Point Defects, Surface 2
There shall be no more than 1 point defect of radius greater than 2 micrometers within the central 15 mm diameter.

There shall be no more than 9 point defects of radius greater than 2 micrometers within the central 30 mm diameter.

The maximum concentration of localized defects over the central 30 mm diameter shall be no more than 30 square micrometers per 1 mm diameter.

Scratch and Point Defect Inspection Method

1. The surface is examined visually by two observers independently. The examination is done against a dark background using a fiber optic illumination system of at least 200 W total power. A 100% inspection of the surface is carried out. Pits and scratches down to 2 micrometers in width can be detected using this method of inspection. Any scratches or sleeks that are detected will be measured using a calibrated eyepiece.

2. Further inspection will be done with a minimum 6X eyeglass using the same illumination conditions, again with two observers. Sleeks down to 0.5 micrometers wide can be detected using this method. The surface will be scanned along one or two chords from center to edge, then at ten positions around the edge, and ten to fifteen positions near the center.

3. An inspection is then carried out with a dark or bright field microscope, with 5x objective at four positions at

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each of the following locations:

a. Within 5 mm of the center of the surface.

b. Equally spaced along the circumference of a centered, 10 mm diameter circle.

Optical Surface Figure, measured over the central 30 mm diameter

Surface 1: Spherical, convex. Radius of curvature: -5.69 m ± 0.06 m.
Astigmatism: < 15 nm Amplitude of the Zernike coefficient $Z_{2,2}$ as defined in Born and Wolf pp. 523-525.

Surface 2: Nominally flat. ROC > | 7000 m |

Surface Error, Low Spatial Frequency: measurement aperture to 1 mm^{-1}

The following root mean square standard deviation (σ_{rms}) values are calculated from the phase maps which are to be provided with each optic. For this calculation the amplitudes for the best fit Zernike terms $Z_{0,0}$, $Z_{1,1}$, $Z_{2,0}$ and $Z_{2,2}$ or corresponding Seidel aberrations are subtracted from the phase map. Known bad pixels may be excluded from this calculation.

Surfaces 1 and 2, Frequency Band: < 1 mm^{-1}
Measured over the central 10 mm diameter aperture: σ_{rms} < 0.5 nanometers
Measured over the central 30 mm diameter aperture: σ_{rms} < 1.0 nanometers

Error, High Spatial Frequency: 1– 750 mm^{-1}

Surfaces 1 and 2 - HSF error $\sigma_{rms} \leq$ 0.3 nanometers

Measured at the following locations:
1. Within 2mm of the center of the surface.
2. Four positions equally spaced along the circumference of a centered, 10 mm diameter circle.
3. Three positions equally spaced along the circumference of a centered, 20 mm diameter circle.

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Inspection

Table 1: Inspections

Specification	Test Method and frequency	Data Delivered
Dimensions	Measurement 100%	Measurement Results
Scratches and Point defects methods 1 and 2	Visual Inspection 100%	Hand sketch including scratch/pit dimensions
Scratches and Point defects method 3	Visual Inspection 100%	Digital image of each inspection location
Figure	Interferometry 100%	Surface phase maps
Errors - Low Spatial Frequency	Interferometry 100%	Surface phase maps
Errors - High Spatial Frequency	Interferometry 100%	Surface maps for 3 central locations. Numerical values included with certification

Orientation: For the purpose of full surface phase maps the data shall be oriented such that the substrate registration mark (arrow) is at the top center of the data.

Format: All Data shall be delivered according to Table 1. In addition to the hard copy, an electronic data set of the phase maps shall be delivered in either ASCII or Vision.OPD format. Include a data description: aperture size, pixel size, height units. Phase difference data shall be in units of nanometers.

WITNESS SAMPLES Requirements:

Material	Low absorption Fused Silica, Grade Corning 0A, Heraeus Suprasil 312 or equivalent.
Diameter:	2.00 in, +/- 0.01 in
Thickness:	0.75 in, +/- 0.01 in
Wedge:	1 deg, +/- 0.1 deg
Bevel:	Bevel polished for safety at 45 deg
Serial Number:	SRM-w1, SRM-w2
Registration Mark:	Serial Numbers and Registration Mark will be etched, ground or sandblasted on the barrel. **An arrow placed within 5 deg of the thinnest point on the barrel indicates Surface 1, the highly reflective surface.**
Sleeks, Scratches and Point Defects:	According to page 2 of this specification (E0900089-v4-D), over the central 30 mm diameter. Inspections will be carried out as explained on pages 2-3 for the main optic.
Surface Figure:	According to page 3 of this specification
Surface Errors:	According to page 3 of this specification (Low and High Spatial Frequency)
Inspections:	All inspections listed in Table 1 page 4 of this specification will be performed for each witness sample and the data will be delivered in a similar format as for the main optic.