Coated Substrate aLIGO Signal Recycling Mirror 33% T

AUTHOR(S)	DATE	Document Change Notice, Release or Approval
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Name: SRM

Applicable Documents

D0901174-v4-D Signal Recycling Mirror Substrate (Substrate Drawing)
E0900089-v4-D Substrate, aLIGO Signal Recycling Mirror (SRM, Substrate Specification)
E080028-A Mirror Blank Material, aLIGO Recycling Mirror 1 (RM1, Blank Specification)

Physical Configuration

Fabricate from: D0901174-v4-D Signal Recycling Mirror Substrate

General to Surfaces 1 and 2

Coating Area: Less than 5 mm from the bevel to the edge of the coating.

Coating Method: Ion Beam Sputtering

Surface Quality: To comply with Advanced LIGO Component Specification E0900089-v4-D, Substrate, aLIGO Signal Recycling Mirror (Page 2): "Scratches and Point Defects".

Figure Change Before/After Coating:

Coating uniformity and stress for the coating process shall not change the saggita more than 5 nm over the central 35 mm diameter aperture, and more than 0.4 nm over the central 10 mm diameter aperture (ROC > 30 Km).

Also, coating process shall not add surface figure Zernike terms higher than the second order with amplitude > 0.5 nm over the central 35 mm diameter and more than 0.3 nm over the central 10 mm.

Witness Sample Durability Testing: Using a representative witness piece per run:

1. Coating to resist adhesion test per MIL-C-48497A 4.5.3.1 Adhesion (snap tape.)
2. Coating to resist humidity test per MIL-C-48497A 4.5.3.2 Humidity (120 F and 95% to 100% relative humidity for 24 hours), combined with before/after spectrometer scan, marking the specimen to ensure the same area is scanned. The scans should be done over the entire spectrometer range, with minimum range covered of 500-1400 nm. There should be no measurable spectral shift.
3. Coating to resist abrasion test per MIL-C-48497A 4.5.3.3 Moderate Abrasion (cheese cloth rub)

Surface 1: HR Coating **Note: Arrow on the optic Barrel points in the direction of Surface 1.**

Coating type: Highly Reflective at 1064 nm

Angle of incidence: Normal (0.0 degrees)

Transmission at 1064 nm: 0.33 ± 0.02 at the designed angle of incidence.

Surface Electric Field: Zero (Goal) < 0.01 V/m (Requirement)

Absorption at 1064 nm: < 1 ppm (Requirement)

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Optical Performance Uniformity	The specified single surface reflectance at the specified wavelength and angle of incidence must be maintained over at least 30 mm diameter aperture.

Surface 2: AR coating

Coating type	Antireflective at 1064 nm
Angle of Incidence	1.45 degrees on the vacuum side, S polarization The horizontally polarized beam will hit the HR surface at normal incidence, but because the optic is vertically wedged, it will exit the AR surface at the above AOI, and will therefore have S-polarization
Reflection at 1064 nm	< 50 ppm (Goal) < 100 ppm (Requirement) at the designed AOI
Absorption at 1064 nm	< 3 ppm
Optical Performance Uniformity	The specified single surface reflectance at the specified wavelength and angle of incidence must be maintained over at least 30 mm diameter aperture.

ADDITIONAL DELIVERABLES: Coating manufacturer to provide:

1. 1" WITNESS SAMPLES for Surfaces 1 and 2:
   Three 1-inch fused silica witness plates (provided by the vendor) from each coating run, which undergo the same coating process as the main optic: HR on one side and AR on the other side. The witness pieces should be superpolished on the HR side and nominally polished and wedged at 0.5 deg on the AR side. The 1-inch coated witness plates should be representative for the individual coating runs.

2. LAYER THICKNESS INFORMATION
   For all layers in the design, measured thickness data from the deposition from each run, designed thickness, and measured indices of refraction over the entire dispersion range (including at 1064 nm) for both coating materials (based on individual layers).

3. SPECTRAL SCANS – Surfaces 1 and 2
   On a representative 1-inch witness sample for each run, the coating manufacturer will provide the following data: a. Spectrophotometer graphs of the Reflectance and Transmittance of each surface (Surface 1 – HR coating and Surface 2 - AR coating) at the specified angles of incidence, over the over the entire spectrometer range, with minimum range covered of 500-1400 nm. The scans will be taken before the sample is coated, between the Surface 1 and Surface 2 coating and after the coating is completed. All spectrometer data to be provided in Excel spreadsheet format, with columnar data in increments of approximately 1 nm.

4. SURFACE DEFECT ANALYSIS - Scratches and point defects:
   a. Hand Sketch:
   i. The surface is examined visually by two observers independently. The examination is done against a dark background using a fiber optic illuminator system of at least 150` 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.

   ii. 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.

b. Digital Images:
An inspection is then carried out with a dark or bright field microscope, with 5X objective at four positions at each of the following locations: i. Within 5 mm of the center of the surface (HR and AR sides). ii. Equally spaced along the circumference of a centered, 10 mm diameter circle (HR and AR sides).

5. DURABILITY TEST DATA & SAMPLES: All samples from the durability tests and data, including spectrophotometer scans of the representative coating on each side in an Excel spreadsheet.