Coated Substrate, ALIGO SIGNAL RECYCLING MIRROR 2

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Name: SR2, F-SR2

Applicable Documents

D0901178-v4-D	Signal Recycling Mirror 2 Substrate (Substrate Drawing - unfolded)
D0901179-v4-D	Folded Signal Recycling Mirror 2 Substrate (Substrate Drawing - folded)
E0900093-v4-D	Substrate, ALIGO Signal Recycling Mirror 2 (SR2, Substrate Specification - unfolded)
E0900094-v4-D	Substrate, ALIGO Signal Recycling Mirror 2 (F-SR2, Substrate Specification - folded)
E080039-A	Mirror Blank Material, AdLIGO Recycling Mirror 2 (RM2, Blank Specification)

Physical Configuration

Fabricated from: D0901178-v4-D Signal Recycling Mirror 2 Substrate, and
D0901179-v4-D Folded Signal Recycling Mirror 2 Substrate

General to Surfaces 1 and 2

Coating Area To Bevel

Coating Deposition Method Ion Beam Sputtering

Surface Quality To comply with Advanced LIGO Component Specification E0900093-v4-D and E0900094-v4-D, Substrate, ALIGO Signal Recycling Mirror 2 (SR2 and F-SR2) (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.

Coated Substrate, ALIGO SIGNAL RECYCLING MIRROR 2

Witness Sample Durability Testing	On 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 (120F and 95% to 100% relative humidity for 24 hr), 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, the Highly Reflective (HR) surface!

Coating type	Highly Reflective **at 1064 nm**
Angle of Incidence (AOI-HR)	SR2: 0.870 degrees on the vacuum side, P polarization F-SR2: 0.878 degrees on the vacuum side, P polarization The two HR coatings for all SR2 and F-SR2 mirrors may have the same design, provided that this design meets the specifications at all angles of incidence.
Transmission at 1064 nm	<15 ppm at the designed AOI-HR.
Transmission in the 670 – 900 nm band	>90% at the designed AOI-HR. To be fine-tuned during negotiations for specific wavelengths.
Transmission at 532 nm	Not specified, but preferably as high as possible at design AOI-HR. Vendor will provide coating design and transmission data for this wavelength (see bellow for Additional Deliverables – point 3).
Absorption at 1064 nm	< 0.5 ppm (Goal), <1 ppm (Requirement)
Optical Performance Uniformity	The specified single surface reflectance at the specified wavelength and angle of incidence must be maintained over at least **50 mm** diameter aperture.

Coated Substrate, ALIGO SIGNAL RECYCLING MIRROR 2

Surface 2: AR coating

Coating type	Antireflective **at 1064 nm**
Angle of Incidence (AOI-AR)	SR2: 1.72 degrees on the vacuum side, unpolarized F-SR2: 1.72 degrees on the vacuum side, unpolarized The beam on the HR surface is p-polarized and the AOI-HR is in the horizontal plane when the mirror is suspended vertically and the arrow is on top of the optic. Because the optic is vertically wedged, the beam will exit the AR surface at the above AOI-AR, but the polarization will neither be P-polarization, nor S-polarization.
Reflection at 1064 nm	<300 ppm at the designed AOI-AR
Reflection in the 670 – 900 nm band	< 0.4 % at the designed AOI-AR
Reflection at 532 nm	Not specified – but preferably low at the design AOI-AR
Optical Performance Uniformity	The specified single surface reflectance at the specified wavelength and angle of incidence must be maintained over at least **50 mm** diameter aperture.

ADDITIONAL DELIVERABLES:

Coating manufacturer to provide:

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 and other wavelengths specified above) for both coating materials (based on individual layers).

3. SPECTRAL SCANS – Surfaces 1 and 2

On a representative 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 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.

Coated Substrate, ALIGO SIGNAL RECYCLING MIRROR 2

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 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.

ii. Farther 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 10 mm of the center of the surface (HR and AR sides).

ii. Equally spaced along the circumference of a centered, 15 mm diameter circle (For F-SR2 on HR side).

iii. Equally spaced along the circumference of a centered, 20 mm diameter circle (For SR2 on HR side).

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.

Coating Specifications for the 2” witness samples: SR2-w and F-SR2-w

Background:

These samples are serialized as SR2-w-01, SR2-w-02, F-SR2-w-01 and F-SR2-w-02.

They will be provided to the coating vendor by University of Florida, and are plano/plano optics polished by the same polishing vendor and to the same specifications as the corresponding main optic (SR2 and F-SR2), over the central 40-45 mm diameter.
The substrates specifications of these samples are listed on page 4 of E0900093-v4-D and E0900094-v4-D.

Coatings Specifications:

The 2” witness samples SR2-w and F-SR2-w will be coated for the same angles of incidence, polarization and using the same HR and AR coating designs as the main optics SR2 and F-SR2 (for all wavelengths listed in this specification).

Their purpose is to allow early or supplementary metrology be performed on these optics rather than on the main optic. They should be representative for the main optic in terms of absorption, surface errors and optical performance (transmission of the HR surface, reflection of AR surface).

The arrow on the barrel of the optic points to the high reflective (HR) surface.

Deliverables:

Spectrophotometer graphs of the Reflectance and Transmittance of each surface as explained at point 3.a. on page 3 of this specification.