Coated Substrate, ALIGO POWER RECYCLING MIRROR

AUTHOR:	CHECKED:	DATE	APPROVALS		
			DCN NO.	REV	DATE
Rodica Martin	Dave Reitze, David Tanner	02-17-10	E0900231	-V1-	
	Dave Reitze	03-18-10		-V2-	
	Dave Reitze	03-31-10		-V3-	

Name: PRM, F-PRM

Applicable Documents

D0901172-v4-D	Power Recycling Mirror Substrate (Substrate Drawing - unfolded)
D0901173-v4-D	Folded Power Recycling Mirror Substrate (Substrate Drawing - folded)
E0900087-v4-D	Substrate, ALIGO Power Recycling Mirror (PRM, Substrate Specification - unfolded)
E0900088-v4-D	Substrate, ALIGO Power Recycling Mirror (F-PRM, Substrate Specification - folded)
E080028-A	Mirror Blank Material, AdLIGO Recycling Mirror 1 (RM1, Blank Specification)

Physical Configuration

Fabricated from: D0901172-v4-D Power Recycling Mirror Substrate, and
D0901173-v4-D Folded Power Recycling Mirror 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 E0900087-v4-D and E0900088-v4-D, Substrate, ALIGO Power Recycling Mirror (PRM and F-PRM) (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.

High average optical power >10 MW/cm^2, sustained

Coated Substrate, ALIGO POWER RECYCLING MIRROR

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)	PRM: NORMAL (0.00 degrees) F-PRM: NORMAL (0.00 degrees)
Transmission at 1064 nm	0.030 ± 0.001 at the designed AOI
Transmission in the 670 – 900 nm band	Not specified, but preferably as high as possible at normal incidence. Vendor will provide coating design and transmission data for this range (see pages 3-4 for Additional Deliverables).
Transmission at 532 nm	Not specified, but preferably as high as possible at normal incidence. Vendor will provide coating design and transmission data for this wavelength (see pages 3-4 for Additional Deliverables).
Surface Electric Field	Zero (Goal), < 0.01V/m (Requirement)
Absorption at 1064 nm	< 0.5 ppm (Goal), < 1ppm (Requirement)
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.

Coated Substrate, ALIGO POWER RECYCLING MIRROR

Surface 2: AR coating

Coating type	Antireflective **at 1064 nm**
Angle of Incidence (AOI)	PRM: 1.45 degrees on the vacuum side, S polarization F-PRM: 1.45 degrees on the vacuum side, S polarization The P-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
Reflection in the 670 – 900 nm band	Not specified – but preferably low at the design AOI
Reflection at 532 nm	Not specified – but preferably low at the design 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) (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 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 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 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.

Coating Specifications for the 2" witness samples (PRM-w and F-PRM-w) and surrogates (PRM-s and F-PRM-s)

Background:

The **2" witness samples** are plano/plano optics, serialized as PRM-w-01, PRM-w-02, F-PRM-w-01 and F-PRM-w-02.

The **2" surrogates** are curve/plano optics with the same radii of curvature as the main optic, serialized as PRM-s-01, PRM-s-02, and F-PRM-s-01.

They will be provided to the coating vendor by the University of Florida, and are polished by the same polishing vendor and to the same specifications as the corresponding main optic (PRM and F-PRM), over the central 30 mm diameter.
The substrates specifications of these samples are listed on page 4 of E0900087-v4-D and E0900088-v4-D.

Coatings Specifications:

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

If possible, the coating should be done in the same coating runs as the main optic.

The purpose of the 2" optics 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).

In addition, the curved/plano 2" optics will be deployed in the interferometer in Advanced LIGO for initial alignment and also used in the early operation stage of the interferometer. For this reason, they are called "SURROGATES".

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

Deliverables:

Spectrophotometer graphs of the Reflectance and Transmittance of each surface as explained at point 3.a. on page 4 of this specification.