A+ Filter Cavity Input Mirror (FIM)

AUTHOR(s):	DATE	Document Change Notice (DCN):	STATUS
G. Billingsley		See DCC record	APPROVED

Contents

1 Applicable Documents

LIGO-D1900148-v1	Mirror Substrate Drawing, A+ Filter Cavity Input Mirror
LIGO-D1900147-v1	Mirror Blank Drawing, A+ Filter Cavity Input Mirror
LIGO-E1900147-v1	Mirror Blank Specification, A+ Filter Cavity Input Mirror

2 Requirements

2.1 Physical Configuration

According to LIGO-D1900148 Mirror Substrate Drawing, A+ Filter Cavity Input Mirror

2.2 Fabricate from

LIGO-D1900147	Mirror Blank Drawing, A+ Filter Cavity Input Mirror
LIGO-E1900147	Mirror Blank Specification, A+ Filter Cavity Input Mirror

2.3 Registration Marks

Registration marks shall be etched, ground or sandblasted and located per LIGO-D1900148

2.4 Bevel

Bevel for safety per LIG-D1900148

A+ Filter Cavity Input Mirror (FIM)

2.5 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.

2.6 Serial Number

Serial Number "FIMXX" shall be shall be etched, ground or sandblasted on the barrel of the optic per D1900148, where XX is incremental starting with 01.

2.7 Surface Quality: Maximum scratch, sleek and point defect area

2.7.1 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 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.

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 each of the following locations:

a. Within 10mm of the center of the surface.

b. Equally spaced along the circumference of a centered, 30 mm diameter circle.

2.7.2 Surface 1, inside 40 mm diameter

Zero defects within the central 40 mm diameter.

2.7.3 Surface 1, between 40 and 60 mm diameter

The total area of defects, within the annular region between 40 and 60 mm diameter, shall not exceed 1400 square micrometers when weighted per Appendix A Defect Analysis.

2.7.4 Surface 1, outside 60 mm diameter

Shall appear transparent with no grey, scuffs or scratches visible to the naked eye when viewed in normal room light against a black background.

2.7.5 Surface 2

The total area of defects within the central 40 mm diameter shall not exceed 2800 square micrometers when weighted per Appendix A Defect Analysis.

A+ Filter Cavity Input Mirror (FIM)

2.8 Optical Surface Figure

measured over the central 40 mm diameter

Surface 1: Spherical, concave. Radius of curvature: Flat, > | 11,250 m |

Surface 2: Convex ROC = 1.00 m, ± 0.01 m

2.9 Surface Error

2.9.1 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 $Z_{0,0}$, $Z_{1,1}$ and $Z_{2,0}$ or corresponding Seidel aberrations are subtracted from the phase map. Known bad pixels may be excluded from this calculation.

Surface 1,
Measured over the central 40 mm diameter aperture: $\sigma_{rms} < 0.5$ nanometers
Measured over the central 60 mm diameter aperture: $\sigma_{rms} < 0.75$ nanometers

Surface 2
Measured over the central 40 mm diameter aperture: $\sigma_{rms} < 20$ nanometers
Measured over the central 60 mm diameter aperture: $\sigma_{rms} < 30$ nanometers

2.9.2 High Spatial Frequency (HSF)

Surface 1 HSF error $\sigma_{rms} \leq 0.1$ nanometers
Surface 2 HSF error $\sigma_{rms} \leq 0.5$ 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, 20 mm diameter circle.

A+ Filter Cavity Input Mirror (FIM)

3 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 defect 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 5 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 is at the top center of the data.

Format: All Data shall be delivered according to Table 1 in electronic format. Electronic data of the phase maps shall be delivered in either ASCII or .dat format.

4 Appendix A. Defect Analysis

The surface defects in weighted areas are to be evaluated as follows.

1. Measure the area of the defect in square micrometers
2. Measure the distance of the defect from the center of the optic
3. Find the weighting factor for the radius measured in step 2, from the table below.
4. Multiply the measured area found in step 1 with the weighting factor found in step 3.
5. Sum all weighted defects found within the analysis zone.

A+ Filter Cavity Input Mirror (FIM)

Inspection radius for FIM (mm)	Position dependent defect Weighting Factor	
	Surface 1	Surface 2
1	None allowed	4.9
2	None allowed	4.6
3	None allowed	4.1
4	None allowed	3.5
5	None allowed	2.9
6	None allowed	2.3
7	None allowed	1.7
8	None allowed	1.2
9	None allowed	0.8
10	None allowed	0.55
11	None allowed	0.34
12	None allowed	0.21
13	None allowed	0.12
14	None allowed	0.065
15	None allowed	0.034
16	None allowed	0.017
17	None allowed	0.008
18	None allowed	0.004
19	None allowed	0.0017
20	None allowed	0.0007
21	0.0007	
22	0.0003	
23	0.0001	
24	4.0E-05	
25	1.4E-05	
26	4.8E-06	
27	1.4E-06	
28	4.0E-07	
29	1.1E-07	