



COMPONENT SPECIFICATION

LIGO II Pathfinder, Large Sapphire Polishing Specification

APPROVALS:		DATE	REV	DCN NO	BY	CHK	DCC	DATE
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Applicable Documents

LIGO-D010032 LIGO II Large Pathfinder Substrate

Requirements

Physical Configuration

Fabricate from
 LIGO-D010032 LIGO II Large Pathfinder Substrate

Scratches, Sleeks and Point defects

Point defects of radius greater than 25 micrometers are treated like scratches for the purpose of this specification. Point defects of radius less than 2.5 micrometers are disregarded.

Scratches and Sleeks, Side 1

The total area of scratches and sleeks within the central 200 mm diameter shall not exceed 50 X 10³ square micrometers (width times length.)

The total area of scratches and sleeks outside the central 200 mm diameter shall not exceed 100 X 10³ square micrometers.(width times length.)

Scratches and Sleeks, Side 2

The total area of scratches and sleeks within the central 200 mm diameter shall not exceed 150 X 10³ square micrometers (width times length.)

The total area of scratches and sleeks outside the central 200 mm diameter shall not exceed 300 X 10³ square micrometers.(width times length.)

Point Defects, Side 1

There shall be no more than 10 point defects within the central 200 mm diameter
 There shall be no more than 100 point defects on the entire surface

Point Defects, Side 2

There shall be no more than 30 point defects within the central 200 mm diameter
 There shall be no more than 100 point defects on the entire surface



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Point Defect Inspection Method

1. The surface is examined visually by two observers independently. The examination is done against a dark background using a fiberoptic 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 centre to edge, then at ten positions around the edge, and ten to fifteen positions near the centre.
3. An inspection is then carried out with a dark field microscope with a similar sampling frequency as described in section 2.

Figure, measured over the central 200 mm diameter

All specified quantities refer to the optical quality of the substrate.

Surface 1: Spherical, concave.

Sagitta: Amplitude of the Zernike coefficient $Z_{2,0}$ as defined in Born and Wolf, $42 \text{ nm} \pm 5 \text{ nm}$

Astigmatism: Amplitude of the Zernike coefficient $Z_{2,2}$ as defined in Born and Wolf, $< 5 \text{ nm}$

Surface 2 - Bulk homogeneity compensation: Nominally flat.

Figuring of surface 2 is intended for compensation of bulk inhomogeneity. There is no explicit requirement for the surface alone, only in combination with the bulk material.

Measured in transmission through Side 2, passing through the material, reflected from Side 1.

Sagitta: Amplitude of the Zernike coefficient $Z_{2,0}$ as defined in Born and Wolf, $73 \text{ nm} \pm 8 \text{ nm}$

Astigmatism: Amplitude of the Zernike coefficient $Z_{2,2}$ as defined in Born and Wolf, $< 8 \text{ nm}$

Error, Low Spatial Frequency

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 amplitude for the best fit Zernike terms $Z_{0,0}$, $Z_{1,1}$, $Z_{2,0}$ and $Z_{2,2}$ is subtracted from the phase map. σ_{rms} for the resultant phase map is defined as the square root of the mean of the square of each pixel value. Known bad pixels may be excluded from this calculation.

Surface 1, Frequency Band: $< 4.3 \text{ cm}^{-1}$

Measured over the central 200 mm diameter aperture:

$\sigma_{\text{rms}} < 0.8 \text{ nanometers}$

Measured over the central 120 mm diameter aperture:

Goal for optimum LIGO system performance $\sigma_{\text{rms}} < 0.4 \text{ nanometers}$

Requirement for this procurement $\sigma_{\text{rms}} < 0.8 \text{ nanometers}$



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Error, Low Spatial Frequency cont'd

Surface 2 - bulk homogeneity compensation, Frequency Band: $< 4.3 \text{ cm}^{-1}$

Measured in transmission through Side 2, passing through the material, reflected from Side 1

Over the central 200 mm diameter aperture:

Goal for optimum LIGO system performance $\sigma_{\text{rms}} < 10$ nanometers

Requirement for this procurement $\sigma_{\text{rms}} < 20$ nanometers

Error, High Spatial Frequency

Surface 1 and Surface 2, Frequency Band: $4.3 - 7,500 \text{ cm}^{-1}$

Goal for optimum LIGO system performance $\sigma_{\text{rms}} < 0.1$ nanometers

Requirement for this procurement $\sigma_{\text{rms}} < 0.2$ nanometers

Measured at the following locations:

1. The center of the mirror substrate.
2. Four positions equally spaced along the circumference of a centered, 80 mm diameter circle.
3. Three positions equally spaced along the circumference of a centered, 120 mm diameter circle.

Inspection

Table 1: Inspections

Specification	Test Method	Data Delivered
Scratches and Point defects	Visual Inspection	Hand sketch including scratch/pit dimensions
Figure	Interferometry	Surface phase map
Errors - Low Spatial Frequency	Interferometry	Surface and transmission phase maps
Surface Errors - High Spatial Frequency	Interferometry	Surface maps for 3 central locations. Numerical values included with certification

Orientation: For the purpose of full surface phase maps the substrate shall be oriented such that the point of minimum thickness shall be at the top center of the data. This location will be marked in indelible ink, with an arrow pointing toward side 1.

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.