



**SPECIFICATION**

**Advanced LIGO  
 Coating Development and Preliminary Production Specifications**

APPROVALS:	DATE	REV	DCN NO	BY	CHK	DCC	DATE
DRAWN: H. Armandula							
CHECKED: G. Billingsley; J. Camp							
APPROVED: D. Coyne							
DCC RELEASE:							

The coating Company will furnish an ion beam sputter deposition system suitable for advanced LIGO substrates, personnel, services, materials and facilities.

Before the LIGO production optics are coated, development work has to take place with a goal to achieve 0.1% coating uniformity for a high reflection (HR) coating over approximately a 21.5 cm diameter and absorption < 1 ppm.

This task will be accomplished during a Coating Development Phase.

**Advanced LIGO Production - Preliminary Specifications**

Number of Core Optics Components (COC's):

Approximately 44 - At least 21 assorted varieties have to be delivered in mid 2004, the rest over the following year.

There will be a number of smaller optical components (~30) with similar coating specifications; these smaller optics are not specified in this document.

The coating in all substrates is to be centered at 1064 nm

Coating thickness uniformity: <0.1% over a 21.5 cm diameter

Scatter: <15 ppm

Absorption: <1 ppm with a goal of 0.05 ppm at 1064 nm

Zero surface electrical field for the HR coatings

**Mirrors**

Substrate materials are: fused silica (~17 substrates) and sapphire (~22 substrates)

Optics sizes range from: 20 cm x 10 cm thick to 35 cm x 14 cm thick

Clear aperture up to 33 cm

Weight up to 40 kg

The optics have wedges ranging from ~30' to 3.4°

Ideally we could coat 2 (32 cm x 13 cm) optics at the same time to achieve optimal transmissin matching.

**Side 1** of the mirrors to have a high reflection (HR) coating, with transmissions ranging from <20 ppm to 12% 0.3%

All coatings are for 0° incidence, unless otherwise specified.

**Side 2** of the mirrors to have an antireflection (AR) coating.

The reflection on these coatings will range from 600 ppm to <100 ppm

Angle of incidence to be equal to the optic's wedge angle.



**COMPONENT SPECIFICATION**

TITLE

**Advanced LIGO Coating Development and Preliminary Production Specifications**

**Beamsplitters: 5 substrates**

The substrate material is fused silica; 35 cm dia. x 6 cm thick. Clear aperture 31 cm

**Side 1** will have a 50/50 coating 1% at 45°, optimized for 'P' polarization

**Side 2** has an antireflection (AR) coating with a reflection of <100 ppm

COC coating requirements are summarized in Table 1

**Table 1:**

Optic Designation:	PRM	SRM	BS @ 45°	FM @ 45°	1st 2 ifo ITM	3rd ifo ITM	ETM
Coating Absorption (ppm)	<1	<1	<1	<1	<1 (0.05 goal)	<1 (0.05 goal)	<1 (0.05 goal)
Thickness Uniformity (%)	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Side 1 (HR) Transmission	*~6.00 % 0.6 %	* 5.00 % to 12.00 %	50 % 1 %	<20 ppm	0.50 % 0.05 %	0.50 % 0.05 %	>1 ppm <20 ppm
Side 2 (AR) Reflection (ppm)	~1000	<100	<100	<300	600 100	600 100	<300
Scatter (ppm)	<15	<15	<15	<15	<15	<15	<15

\* Depends on ITM and ETM material selection

More detailed information about the characteristics of these optics can be found in Appendix A

**Surface Quality**

**Scratches and Point Defects**

Points 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 Side 1**

The total area of scratches within the central 21.5 cm shall not exceed  $25 \times 10^3$  square micrometers (width times length).

The total area of scratches within the central 21.5 cm shall not exceed  $250 \times 10^3$  square micrometers.

**Scratches Side 2**

The total area of scratches within the central 21.5 cm shall not exceed  $75 \times 10^3$  square micrometers (width times length).



## COMPONENT SPECIFICATION

TITLE

### Advanced LIGO Coating Development and Preliminary Production Specifications

The total area of scratches within the central 21.5 cm shall not exceed  $750 \times 10^3$  square micrometers .

#### Point Defects Side 1

There shall be no more than 10 point defects within the central 21.5 cm 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 21.5 cm diameter.

There shall be no more than 100 point defects on the entire surface.

#### Inspection Method

1. The surface is examined visually by two observers independently. The examination is done against a dark background using a three-bundle fiberoptic illumination system of 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 that are detected will be measured using a calibrated eyepiece.
2. Further inspection will be done with a 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 of two chords from center to edge, then at 10 positions around the edge, and ten to fifteen positions near the center
3. An inspection is then carried out with a dark field microscope with a similar sampling frequency as described in section 2.
4. No blemishes such as streaks, smears, stains, discoloration, fogging are allowed within the clear aperture when inspected according to inspection Method 1 above.

Laser fluence expected to be  $<100 \text{ Kw/cm}^2$

#### NOTES:

The coating manufacturer has to supply:

1. One 1" witness plate from each coating run
2. Spectrophotometer graphs of the reflectance and transmittance of the HR coating
3. Spectrophotometer graph of the reflectance of the AR coating



# COMPONENT SPECIFICATION

TITLE

## Advanced LIGO Coating Development and Preliminary Production Specifications

### Appendix A - Coc's - Substrate Specifications

	PRM	SRM	BS	FM	1st 2 ifo ITM	3rd ifo ITM	ETM
Wedge	3.4	3.4	1.3	1.1	1.1	1.1	2
Baseline Optic size (mm)	254 x 100	254 x 100	350 x 60	350 x 118	320 x 130	320 x 130	320 x 130
Fall back optic size (mm)	254 x 100	254 x 100	350 x 60	350 x 140	350 x 140	350 x 140	350 x 140
Total Number 44	7	7	5	3	8	4	10
Baseline Material (fall back material is all FS)	Low inclusion FS	Low inclusion FS	Low absorption FS	FS	Sapphire	Sapphire	Sapphire
Clear Aperture	224	224	330	330	300	300	300
Sagitta (nm) over central 215 mm dia (2*wo dia)	240 TBD	240 TBD	Flat TBD	Flat TBD	165 10	165 10	165 10
Surface error -TPA (nm rms) over central 215 mm diameter	< 1.6	< 1.6	< 1.6	< 1.6	< 0.8	< 0.8	< 0.8
Microroughness spec over central 215 mm dia (nm rms)	< 0.4	< 0.4	< 0.4	< 0.4	< 0.2	< 0.2	< 0.2
Microroughness goal over central 215 mm dia (nm rms)					< 0.1	< 0.1	< 0.1