BS05-B

LIGO-T990138-00-D

BLANK

A. DCN: LIGO-T970204-00-D **LIGO DETECTOR OPTICS**

B. LIGO S/N: BS Ø5 **Incoming Inspection Check-off Sheet**

Core Optics Blank Material

The purpose of this sheet is to verify material physical dimensions, perform visual inspection, and to facilitate material traceability of LIGO Detector optics. This sheet is to be included in the LIGO Quality Assurance traceability file. Complete a check-off sheet for each optic blank received and inspected.

C. LIGO Contract No.: PC 208421

D. Glass Mfg./Order No: Heraeus/5001652

E. Core optic Material: (BS) / FM / ITM / ETM / RM)

F. Glass Mfg. Part No.: 50785

G. LIGO Drawing No.: D960793-B-D

H. Manufacturer's Boule No.: MF.F 8957

I. Date Received at Caltech: 12-01-97

J ☑ Verify glass manufacturer's ~~Certification~~ inspection report against LIGO Component Specification No. E960094-A-D
Attach the applicable Component Specification Verification sheet.

K ☑ Attach a copy of the glass manufacturer's ~~Certification~~ inspection report to check-off sheet.

L ☑ Attach the glass manufacturer's birefringence map, ~~inclusion map~~, and data sheet per the above Component Specification. No inclusion map present

M ☑ Visually inspect for shipping container for damage. If applicable, describe the damage on attached.

N ☑ Visually inspect the blanks for damage, for chips on surfaces and edges, or for other defects. If applicable, describe damage/defects on attached sheet.

O ☑ Verify core optic blank physical dimensions per applicable LIGO drawing.

☑ Inspection of material diameter. Diameter 10.11 in 256.70 mm

☑ Inspection of material thickness. Thickness 2.08 in 52.84 mm

P ☑ Verify that the Registration Mark is present (with arrow pointing to the first surface) as required by LIGO Component Specification. No registration marks present

Q ☑ Verify receipt of 25mm X 25mm cylinder Witness Sample(s) required by the LIGO Component Specification and visually inspect for damage. Describe damage on the attached sheet. Shipped directly to Heraeus (France)

R ☑ Sign and date original packing slip (shipper) and distribute per paragraph 3.R.

Inspect By: [signature] Date Inspected: 12-02-97

Reviewed and/or accepted by:

Cognizant Engineer: _____ Date: _____

LIGO QA Officer or Designee: _____ Date: _____

LIGO DETECTOR OPTICS
Incoming Inspection Check-off Sheet

Core Optics Blank Material

COMMENTS/DISCREPANCIES: (Disposition damage/discrepancies per LIGO Quality Assurance Plan (LIGO M960076-00-P) paragraphs 5.12 and 5.12.1.)

No registration marks

No data disc

No birefringence or inclusion map (report ø inclusions)

Witness sample is being sent directly to Heraeus (France) by direction.

Serial number not marked correctly - wrong serial number

OH content not reported

SKETCHES:

DISPOSITIONS:

LIGO Component Specification Verification Sheet
Mirror Blanks, Beam Splitter

Mirror Blanks, Beam Splitter		Serial Number: BSØ5	Specification	Reported Value	✓
	Requirements	**Physical Dimensions**	LIGO-D960793-B		✓
		Diameter	256mm +1.0mm, -0mm	256.7 mm	✓
		Thickness	52 ~~61~~mm +1.0mm, -0mm	52.84 mm	✓
		Chamfer	2.0mm Max 2pl		
		Clear Aperture	Central 235mm		
		Material	Fused Silica Suprasil ~~#7980~~ 311 S	Certification	✓
		Registration Mark	"Top" of Optic, 80mm Arrow Points to Side 1	Certification	No
		Witness Sample	25mm dia. x 25mm cylindrical	Shipped direct	✓
		Witness Sample Map		Map Attached	✓
		Defect Depth	< 0.5mm	Hand Sketch w/location & dim.	No
		Homogeneity Within the Central 150mm	≤ 5.0 x 10^{-7} p – v λ = 632.8nm	Interferogram Homogeneity Map	✓
		Homogeneity Within the Central 225mm	≤ 2.5 x 10^{-6} p - v λ= 632.8nm	Interferogram Homogeneity Map	✓
		Homogeneity Data	ASCII Format	PC Compatable 3½ in. Disk	No
		Birefringence Within the Central 150mm	≤ 1 nm/cm	Certification, Birefringence Map	✓
		Birefringence Within the Central 225mm	≤ 5 nm/cm	Certification, Birefringence Map	✓
		Bubble & Inclusion within the clear aperture. Max. Inclusion Diameter	Total ≤0.03mm^2 Per 100cm^3 of Glass. ≤ 0.1mm	Hand Sketch w/location & dim.	✓
		Absorption	2ppm/cm λ = 1.06nm	Certification	No
		Striae within the Clear Aperture	Grade A per MIL-G-174	Inspection Report	✓

Blnk_BS.doc

OH: _____

Heraeus QUARZGLAS
POL-QW

INSPECTION REPORT

Project LIGO

Customer	: HERAEUS Amersil Inc. Duluth, Ga 30136-5821
Order No.	: 45000023300dtd 30.09.96 as
HAI-Order No.	: none
HQS-Order No.	: 94908401
Item No.	: 2
Quality	: Fused silica Suprasil 311 S
HQS melt No.	: MF.F 8957
Marking	: 960095-IM 17 - B505 BN 5058

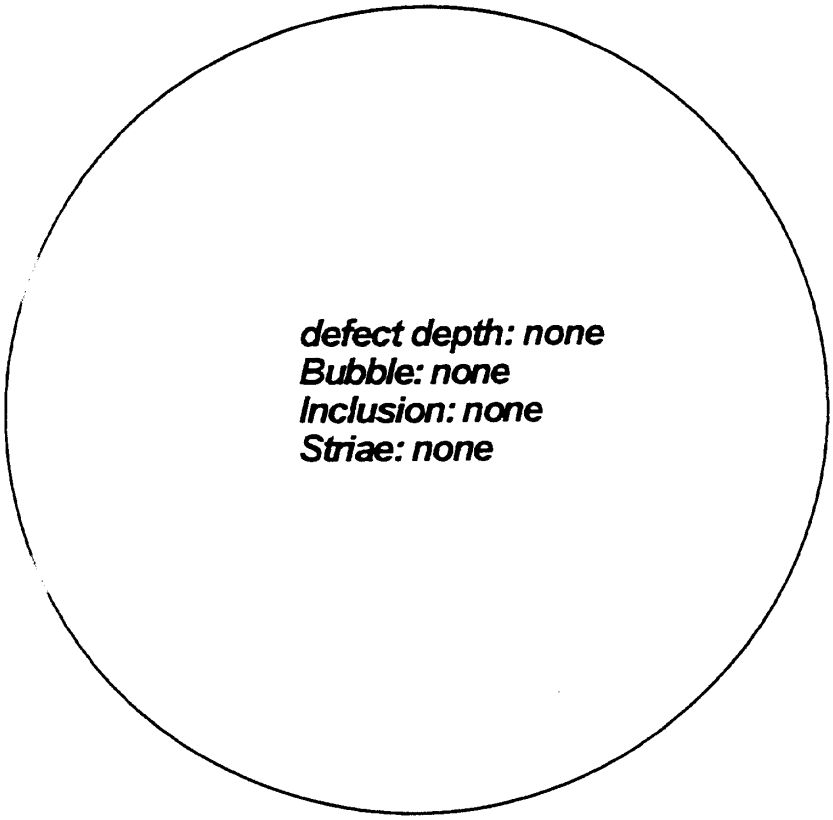
Diameter		: 256,7mm
CA Diameter		: Ø 200 mm = 1,69xE^{-6}
Thickness		: 52,84 mm
Edge		: 0,3 - 0,5 mm
Parallelism		: 0,08 mm
Roughness		: ground
	R_a	: 1,08 µm
	R_t	: 8,86 µm
Bubble class		: 0 ; none bubbles
Birefringence		: CA Ø200 mm <= 5nm/cm;
Homogeneity		: see Interferogram
Striae Grade		: A
Granularity		: none
Remark		: Test Sample (Ø25 x25 mm) with the same marking

POL - Qualitätsprüfung Optik

Date : 06.10.1997

Inspector :Wink

Heraeus QUARZGLAS POL- QW	Order Nr.: 94908401 Pos.: 2 Ø256,7 mm x 52,84 mm Quality: Suprasil 311 Plate No.: 960095-IM17/5058	Date: 6.10.97 Inspector:



Diameter	0,03mm	0,05mm	0,08mm	0,12mm	0.2mm	0,31mm	Sum
piece							
mm^2							

TBCS= mm^2 /$100cm^3$

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Heraeus QUARZGLAS

POL - QW

Order No.: 94908401 Pos.: 2

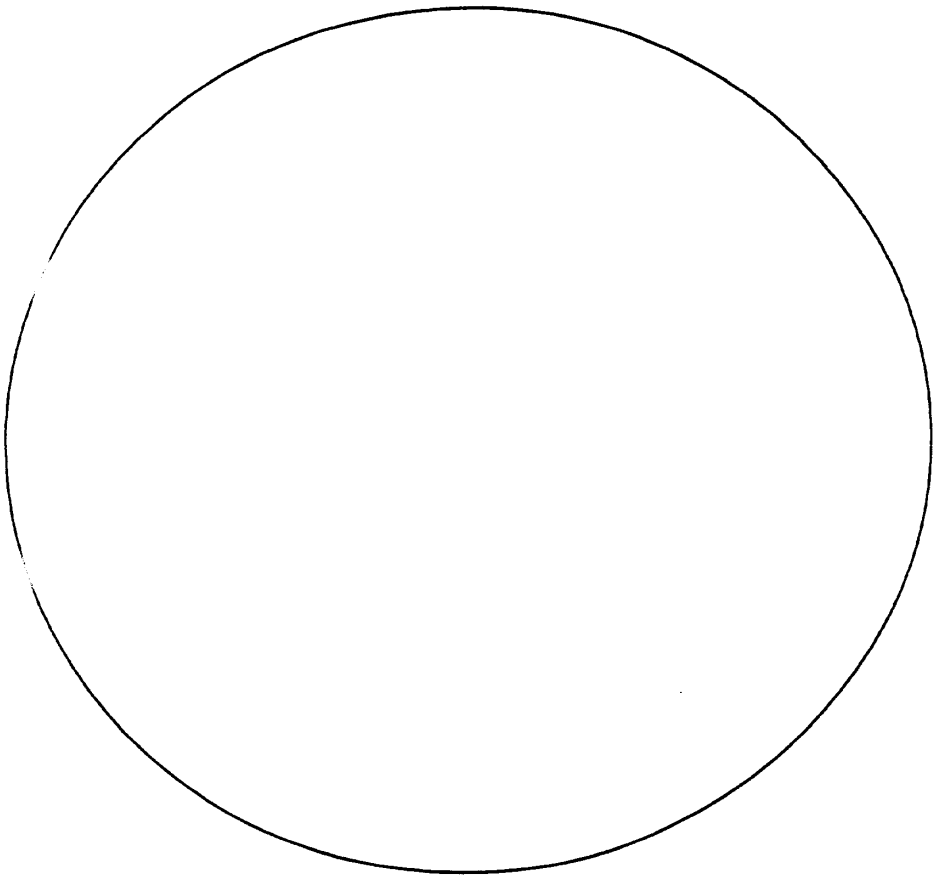
Ø 256,7 mm x 52,84 mm

Plate No.: 960095-1M17/5058

Residual strain- Report

Date: 6.10.97

Inspector:



Edge	Center						Pos.
10							nm
2	<1						nm/cm

Beam splitter, Suprasil 311 S
Ø 256mm x 52 mm

HQS-Order No.: 94908401

Date: 28.11.97 Ko

q:\interfer\sonder\ligo\ligo.wk4

HAI order No.: 5000023300dtd 30.09.96 as

Ligo Serial No.	HQS Serial No.	BN	witness sample No.	OH-content [ppm]	Homogeneity [ppm]			
					Delta n -(Tilt)		Delta n -(Tilt + Focus)	
					Ø 225 mm	Ø 80 mm	Ø 225 mm	Ø 80 mm
960094-BS01	960095-IM13	5061	960095-IM13 or 5061	153,9	1,21	0,217	0,499	0,171
960094-BS02	960095-IM14	5057	960095-IM14 or 5057	142,2	0,822	0,166	0,649	0,162
960094-BS03	960095-IM15	5059	960095-IM15 or 5059	201,9	0,606	0,133	0,603	0,13
960094-BS04	960095-IM16	5060	960095-IM16 or 5060	202,7	0,993	0,179	0,673	0,14
960094-BS05	960095-IM17	5058	960095-IM17 or 5058	198	2,425	0,245	1,551	0,27
960094-BS05	960095-IM18	5062	960095-IM18 or 5062	198,8	0,891	0,236	0,796	0,235

Input Test Mass, Recycling Mirror, End Test Mass; Suprasil 312 S
Ø 256 mm x 108 mm

Ligo Serial No.	HQS Serial No.	BN	witness sample No.	OH-content [ppm]	Homogeneity [ppm]			
					Delta n -(Tilt)		Delta n -(Tilt + Focus)	
					Ø 200 mm	Ø 80 mm	Ø 200 mm	Ø 80 mm
960095-IM1	960095-IM1	5397	960095-IM1 or 5397	151,8	1,582	0,224	0,677	0,12
960095-IM2	960095-IM2	5394	960095-IM2 or 5394	293,7	1,526	0,271	0,604	0,099
960095-IM3	960095-IM3	5013	960095-IM3 or 5013	210,9	1,899	0,309	0,466	0,092
960095-IM4	960095-IM4	5319	960095-IM4 or 5319	255,3	0,741	0,151	0,389	0,108
960095-IM5	960095-IM5	5318	960095-IM5 or 5318	308,5	0,871	0,256	0,546	0,177
960095-IM6	960095-IM6	5056	960095-IM6 or 5056	226,6	0,736	0,25	0,478	0,161
960095-IM7	960095-IM7	5055	960095-IM7 or 5055	199,3	1,19	0,195	0,527	0,129
960095-IM8	960095-IM8	5395	960095-IM8 or 5395	167,3	1,719	0,148	0,98	0,148
960095-IM9	960095-IM9	5014	960095-IM9 or 5014	153,1	2,325	0,278	0,503	0,097
960095-IM10	960095-IM10	5054	960095-IM10 or 5054	154	2,27	0,295	0,44	0,113
960095-IM11	960095-IM11	5396	960095-IM11 or 5396	257,3	0,432	0,198	0,461	0,212
960095-IM12	960095-IM12	6653	960095-IM12 or 6653	309,5	1,907	0,31	0,971	0,32
960095-IM13	960095-IM19	7273	960095-IM19 or 7273	KW 50	1,431	0,28	0,345	0,087

Heraeus
QUARZGLAS

POL-QW

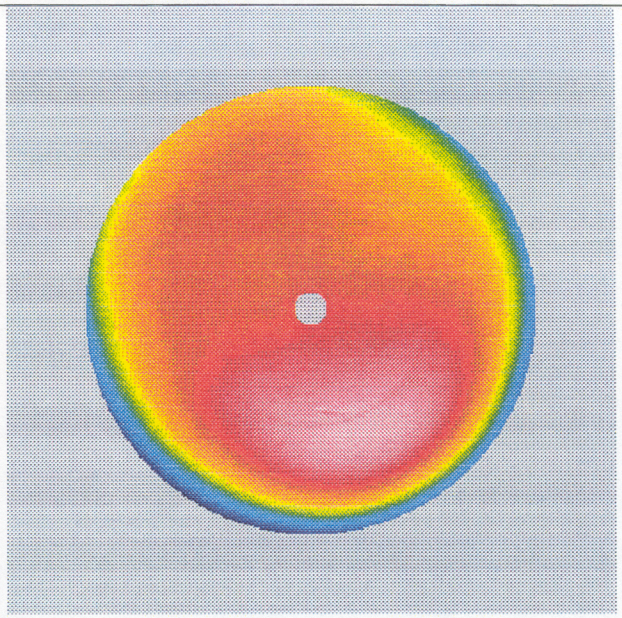
Data taken at 632.8 nm

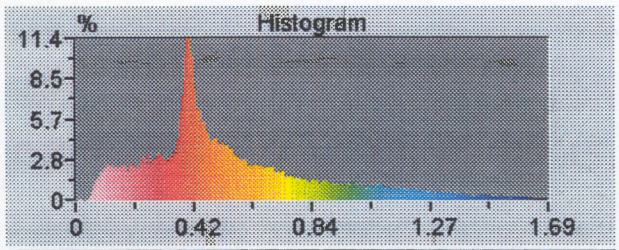
Date: 04.09.97 Operator: Rt
ID: 505800 No.:

HQS-Order-No.: 98492874
Customer: HAI
Product: LIGO
Pos.-No.: 2
Order-No.:
Comment: 960094-im-[redacted]
17

thickness: 53.0 mm
sample diameter: 280.0 mm
CA diameter: 200.0 mm
examined diameter: 200.3 mm

Center: (0.0mm,0.0mm)
Radius: 100.1mm
Points: 69729



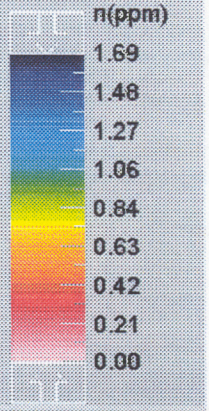


Sub. Terms		Magn.	Angle
X	Tilt	0.2735	-74.7798
	Focus	0.3919	
	Astigm.	0.2043	-53.9953
	Coma	0.3261	97.8472
	SA3	0.2647	

Phase Data

Unit	n(ppm)
PV:	1.69
RMS:	0.295
Scale:	0.5

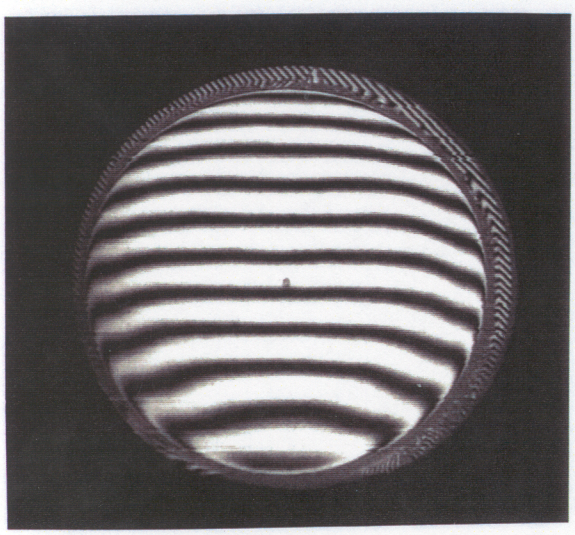
Contrast



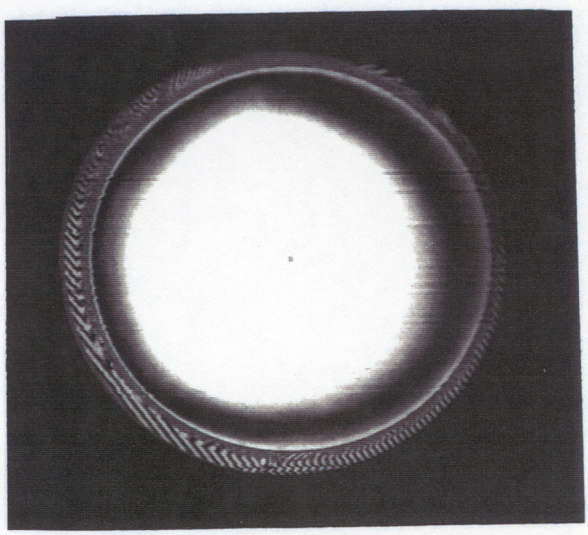
Reset

UpperL	1.689
LowerL	0.000

File: 505800.tif, 04.09.97, 17:12
XPS-12"



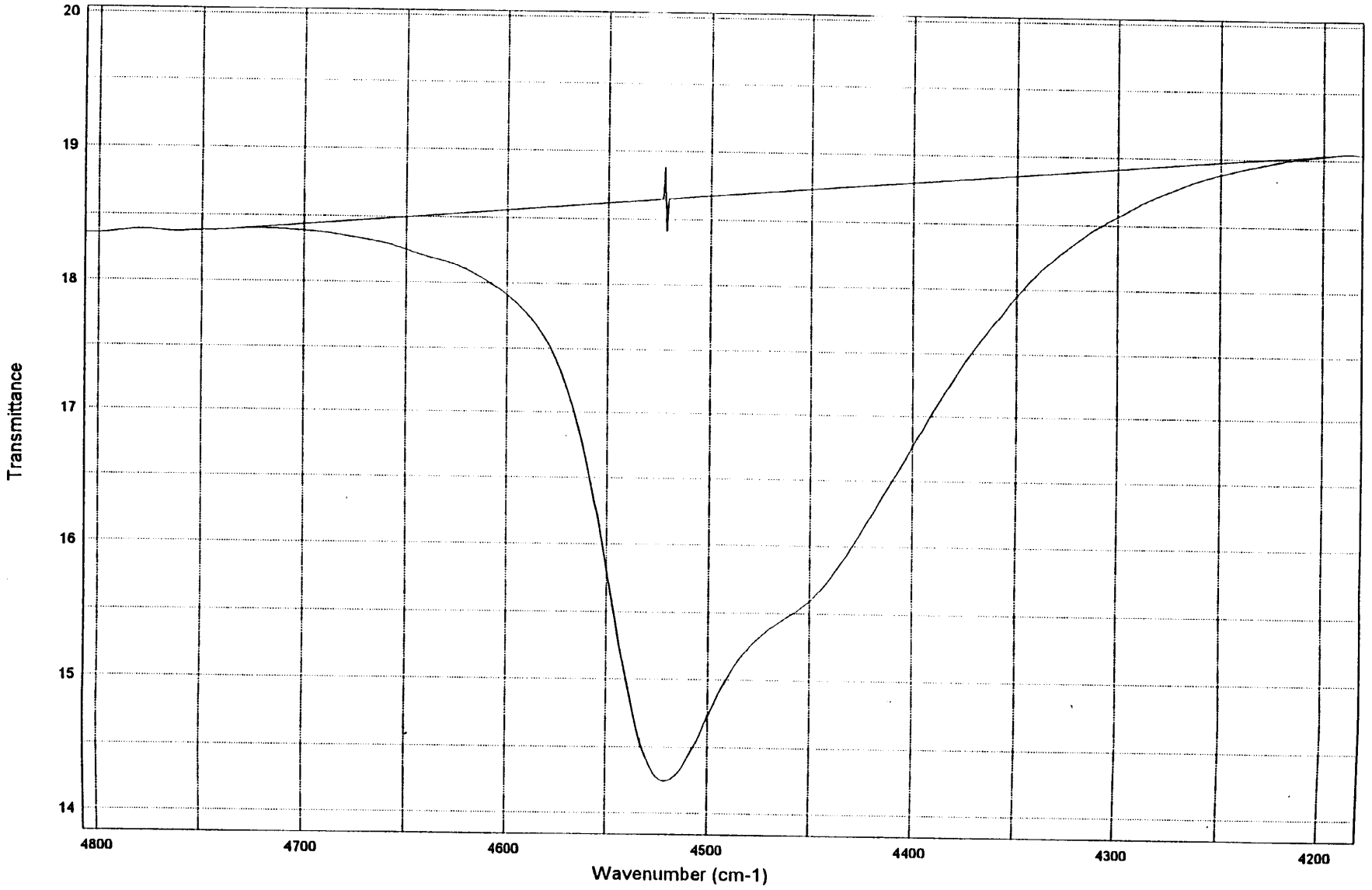
BSØ5



I0=18.6502 , I1=14.2458 at x=4521 OH-content: 198 ppm

Heraeus
QUARZGLAS

MEASURE NO. : 5058
DATE : 05.09.1997 TIME : 12:30
MEASURE START : 10000 1/cm
MEASURE END : 2500 1/cm
OP-DISK-PATH LENGTH : Ko-203-PL: 2.60 cm / Order No.: 9930 3974 / Material: 5058----OH-content: 198 ppm at x=4521



Heraeus
AMERSIL

Heraeus Amersil Inc
3473 Satellite Blvd.
Duluth, GA 30096

Delivery Note/ Packing List

Sales Order #: 5001652
Delivery #: 30039279

Terms: FOB Duluth
Customer PO #: pc208421

SOLD TO: Customer # 1658
CALIFORNIA INST OF TECH
ACCOUNTS PAYABLE 201-6
PASADENA, CA 91125
USA

SHIP TO: CUSTOMER # 5594
CALIFORNIA INST OF TECH
Attn: Gari Billingsley
391 SOUTH HOLLISTON
PASADENA, CA 91125
USA

Order Date: 09/24/1996
Account #:
Tracking #: 1Z3944240200060485
0476 0467 0458 0449 0430

Salesman: 00000020 MARC SCHNEIDER
Route: UPS002 UPS Blue 2 Day PPA
Total Weight: 252.000 LB
Shipping Cartons: 00006

LINE ITEM	MATERIAL NUMBER	DESCRIPTION	UOM	SHIP DATE	NOTICE	CURRENT SHIPMENT
000001	50785	DISC, SUP 311, G, 256 X 52 SUPRASIL 311 DISC, GROUND, 256MM DIA X 61MM THK. PER LIGO PROJECT DRAWING D960793-A-D REV A AND SPECIFICATION LIGO-E960094 REV A	EA	11/24/1997	Open cartons and compare to bill of lading and packing list promptly. Claims for shortages or breakage must be made within 15 days after receipt of goods. Unpack with great care. Please do not discard the packing case nor any of the packing material until contents of case have been carefully checked and found correct and in good order. In case of damaged materials regardless of the external condition of the cartons, the consignee must institute the following procedure. Where shipments are made FOB Point of Shipment, it is the consignee's responsibility to file claim with the carrier and obtain an inspection report from the carrier for truck, air freight or parcel post shipments. For UPS shipments or FOB Destination shipments, all requests for inspection of damaged material should be made by the shipper and the consignee must notify Heraeus-Amersil Inc. promptly of such breakage to institute a claim. Damaged material, packing material, and packing case must be retained for carrier's inspection. Return no goods unless authorized. If material is not satisfactory, notify us and hold material subject to our order.	6.000

Received complete
12-02-97

JM

SUBSTRATE

A. DCN: LIGO-T970204-01-D **LIGO DETECTOR OPTICS**
B. LIGO S/N: BS05-B **Incoming Inspection Check-off Sheet**
Core Optics Polished Substrate

The purpose of this sheet is to verify material physical dimensions, perform visual and microscopic inspection, and to facilitate material traceability of LIGO Detector optics. This sheet is to be included in the LIGO Quality Assurance traceability file. Complete a check-off sheet for each optic blank received and inspected.

C. LIGO Contract/Purchase No.: PC167159 D. Substrate Polisher: CSIRO

E. Core optic Material: (BS) FM / 2ITM / 4ITM / ETM / RM F. Date Received: 10-09-98

G ☑ Verify glass polisher's Certification with LIGO Component Specification No. E960100-B-D. Attach the completed LIGO Component Specification Verification Sheet.

H ☑ Attach a copy of the glass polisher's Certification Document and data sheet to check-off sheet.

I. ☑ Verify receipt of an IBM PC compatable disc in ASCII format of all Surface Data per the applicable LIGO Component Specification sheet

J ☑ Attach the surface maps supplied by vendor per above Component Specifications to the check off sheet.

K ☑ Visually inspect for shipping container damage. If applicable, describe damage on attached sheet and notify the Cognizant Engineer

L ☐ Visually inspect the polished substrate for shipping damage, for chips on surfaces and edges, or for other defects. If applicable, describe damage/defects on attached sheet and notify Cognizant Engineer.

M ☑ Verify polished substrate's physical dimensions per applicable LIGO drawing.

☑ Inspection of material diameter.	Diameter	9.88	in	250.97	mm
☑ Inspection of material thickness	Thickness	1.57	in	39.97	mm
☑ Wedge Angle 1° Ø'					

N ☑ Verify that the Serial Number is present in the proper format as required by LIGO Component Specification.

O ☑ Verify that the Registration Mark (line with arrow pointing toward surface #1) is present as required by LIGO Component Specification.

P ☑ Inspect the sides and bevels with the naked eye in normal room light and against a black background to verify that there is no gray, scuffs or scratches per the applicable LIGO Component Specification.

Q ☑ Use a dark field microscope at 5X magnification to inspect the polished optic for scratches and defects over the central 80 mm diameter per the applicable LIGO Component Specification.

R ☐ Sign and date original packing slip (shipper) and distribute per paragraph 3.R.

Inspection By: _____ Date Inspected: _____

Reviewed and/or accepted by:

Cognizant Engineer: _____ Date: _____

LIGO QA Officer or Designee: _____ Date: _____

FM300

Figure 1

LIGO DETECTOR OPTICS
Incoming Inspection Check-off Sheet

Core Optics Polished Substrate

COMMENTS/DISCREPANCIES: (Disposition damage/discrepancies per LIGO Quality Assurance Plan (LIGO M960076-00-P) paragraphs 5.12 and 5.12.1.)

SKETCHES:

See CSIRO drawings indicating sizes and locations of scratches.

DISPOSITIONS:

Substrate, Beam Splitter	Serial Number: BSØ5-B		Specification	Reported Value	✓
	Surface 1	Surface Figure Over Central 200mm dia.	Flat		
		Radius of Curvature	> 200 km convex > 720 km concave	>8,000Km (0.6nm)	✓
		Astigmatism	< 16nm p-v	5.6 nm	✓
	Surface 2	Surface Figure Over Central 200mm dia.	Nominally Flat		
		Radius of Curvature of the Wavefront	> 140 km convex > 500 km concave	290 Km (17.2nm)	✓
		Astigmatism	< 23nm p-v	3.8 nm	✓
	Surface Errors	Low Spatial Frequency Band Central 80mm	≤ 4.3 cm^{-1} σ_{rms} < 1.6nm	S1 1.2 nm S2 1.1 nm	✓ ✓
		Low Spatial Frequency Band Central 200mm	≤ 4.3 cm^{-1} σ_{rms} < 3.2nm	S1 1.5nm S2 1.3 nm	✓ ✓
		High Spatial Frequency Band Central 80 & 200 mm	≤ 4.3 – 7,500 cm^{-1} σ_{rms}<0.4nm	[redacted] S1 0.11nm S2 0.13nm	✓ ✓

Scratches, Point Defects & Polish		Specification	Certification	✓
	Scratches	The Total Area of scratches within the central 80mm diameter shall not exceed 75 X 10^3 square micrometers (width x length).	Hand Sketch w/dimensions	✓
		The total area of scratches outside the central 80 mm diameter shall not exceed 750 x 10^3 square micrometers. <50,000 S1 <25,000 S2	Hand Sketch w/dimensions	✓
	Point Defects	There shall be no more than 30 point defects within the central 80mm diameter.	Hand Sketch w/dimensions	✓
		There shall be no more than 100 point defects on the entire surface. 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.	Hand Sketch w/dimensions	✓
	Side/Bevel Polish	Sides and bevels shall be polished from a three micrometer grit finish. These surfaces shall appear transparent with no gray, scuffs or scratches visible to the naked eye when viewed in normal room light against a black background.	Inspection Report	✓

LIGO Component Specification Verification Sheet
Beam Splitter

LIGO-C982167-00-D

Telecommunications & Industrial Physics

Bradfield Road, West Lindfield
PO Box 218
Lindfield NSW 2070
Tel: 9413.7620
Fax:9413.7200

LIGO Document Control Center
C/o Linda Turner
LIGO Project, Mail Code 51-33
California Institute of Technology
Pasadena CA 91125
USA

Certification data – BS05 (Attention: Garilynn Billingsley)

Please find enclosed a certification package for LIGO Core Optics Component BS05, manufactured by CSIRO under purchase order PC167159. An invoice for this component is also enclosed.

Regards

Chris Walsh
Optics and Surface Science

This Certification Package relates to the following substrate: **Beamsplitter**

Serial number: BS05-B

The Package consists of the following documents:

1. Printed documents

HABA - LIGO - C - PD:	Certification of Physical Dimensions and Registration Mark location, orientation and dimensions
HABA - LIGO - C - SB:	Certification of Side and Bevel Polish
HABA - LIGO - C - SP:	Certification of Scratches and Point Defects
HABA - LIGO - C - SN:	Certification of Serial Number location, dimensions
HABA - LIGO - C - SF:	Certification of Surface Figure for Sides 1 and 2 and transmitted wave front
HABA - LIGO - C - SL:	Certification of Surface Errors - Low Frequency, for Sides 1 and 2
HABA - LIGO - C - SH:	Certification of Surface Errors - High Frequency, for Sides 1 and 2
Attachment 1	Hard copy print out of LADI data for Side 1 with piston, tilt removed and also for piston, tilt, power, astigmatism removed
Attachment 2A	Hard copy print out of LADI data for Side 2 with piston, tilt, removed and also for piston, tilt, power, astigmatism removed
Attachment 2B	Hard copy print out of LADI data for transmitted wave front in measurement configuration where beam enters through side 2, reflects from side 1 and exits through side 2, with piston, tilt removed and also for piston, tilt, power, astigmatism removed
Attachment 3	Hard copy printouts of TOPO 2D data obtained with 2.5X and 40X heads at three central positions (side 1)
Attachment 4	Hard copy printouts of TOPO 2D data obtained with 2.5X and 40X heads at three central positions (side 2)

2. Electronic data

Surface maps for sides 1 and 2 are available at the CSIRO ftp site under the following file names:

LADI data:	BS_51.zip	(Side 1)	BS_52.zip	(Side 2)
			BS_5T.zip	(wave front)
TOPO data: (2.5X)	T2BS51A.asc	(Side 1)	T2BS52A.asc	(Side 2)
	T2BS51B.asc		T2BS52B.asc	
	T2BS51C.asc		T2BS52C.asc	
(40X)	T4BS51A.asc		T4BS52A.asc	
	T4BS51B.asc		T4BS52B.asc	
	T4BS51B.asc		T4BS52C.asc	

1	**Substrate Type:**	**Beamsplitter**
2	**Serial Number:**	**BS05-B**
3	**Physical quantity certified:**	**Physical Dimensions and Registration Mark**
4	**LIGO specification reference:**	**D960789-B-D**
5	**CSIRO measurement/inspection procedure reference:**	**HABA-LIGO-M-PD**
6	**Variations to the measurement/inspection procedure:** (indicate Yes/No and attach separate sheet if Yes)	**No**
7	**CSIRO Log Book Reference**	**LN00028 p.31**
8	**Team member responsible for measurement/inspection:**	**R Yin**
9	**Measurement/inspection results reviewed by:**	**C Walsh**

10. Results

[Measurement errors ($\pm 1\sigma$) shown only where they are comparable to tolerances specified or when measurement is within 2σ of boundary of acceptability]

Physical Quantity	Result
Diameter	250.97 mm
Cylindricity	< 0.01 mm
Thickness (maximum - for FM, RM, ETM) (minimum - for BS)	 39.97 mm
Bevel as per drawing (height, angle):	(S1) Height: 2.2 mm Angle:$45^0$06' (S2) Height: 2.2 mm Angle:$44^0$36'
Wedge angle:	$1^0$0'
Location of registration mark ($\pm$ angle with respect to minimum part thickness):	$0^0$1'
Location of other 3 marks (with respect to registration mark at minimum thickness)	$89^0$59',$180^0$0',$270^0$0'
Registration mark dimensions (OK/ not OK)	OK

11. Certification

The measurements and inspection data presented in this report were obtained using the procedures outlined in the relevant CSIRO procedures document (sec. 5). These results have been reviewed against the LIGO specifications (sec. 4). Taking into account the variations (if any) from these measurement procedures noted in sec.6, CSIRO certifies the substrate to comply with the LIGO specification for this physical quantity.

Project Manager:  Chris Walsh

Date: 25 Sept 98

1	**Substrate Type:**	**Beamsplitter**
2	**Serial Number:**	**BS05-B**
3	**Physical quantity certified:**	**Side and Bevel Polish**
4	**LIGO specification reference:**	**E960100-B-D**
5	**CSIRO measurement/inspection procedure reference:**	**HABA-LIGO-M-SB-A**
6	**Variations to the measurement/inspection procedure:** (indicate Yes/No and attach separate sheet if Yes)	**No**
7	**CSIRO Log Book Reference**	**LN00062**
8	**Team member responsible for measurement/inspection:**	**Edita Pavlovic**
9	**Measurement/inspection results reviewed by:**	**J Seckold**

10. Results

Defects, if any, in the side and bevel polish compared to the LIGO specification (4 above) are detailed below *(team member to note defects here; if none seen, note "no defects observed").*

No defects observed

11. Certification

The measurements and inspection data presented in this report were obtained using the procedures outlined in the relevant CSIRO procedures document (sec. 5). These results have been reviewed against the LIGO specifications (sec. 4). Taking into account the variations (if any) from these measurement procedures noted in sec.6, CSIRO certifies the substrate to comply with the LIGO specification for this physical quantity.

Project Manager:  Chris Walsh

Date: 25 Sept 98

1	**Substrate Type:**	**Beamsplitter**
2	**Serial Number:**	**BS05-B**
3	**Physical quantity certified:**	**Serial Number and location**
4	**LIGO specification reference:**	**E960100-B-D**
5	**CSIRO measurement/inspection procedure reference:**	**HABA-LIGO-M-SN-A**
6	**Variations to the measurement/inspection procedure:** (indicate Yes/No and attach separate sheet if Yes)	**No**
7	**CSIRO Log Book Reference**	**LN00062**
8	**Team member responsible for measurement/inspection:**	**E Pavlovic**
9	**Measurement/inspection results reviewed by:**	**J Seckold**

10. Results

Quantity inspected	Result of Inspection (OK / not OK)
Location of serial number as per drawing (sec. 4)	OK
Orientation of serial number as per drawing (sec. 4)	OK
Height of lettering	OK

11. Certification

The measurements and inspection data presented in this report were obtained using the procedures outlined in the relevant CSIRO procedures document (sec. 5). These results have been reviewed against the LIGO specifications (sec. 4). Taking into account the variations (if any) from these measurement procedures noted in sec.6, CSIRO certifies the substrate to comply with the LIGO specification for this physical quantity.

Project Manager: Chris Walsh

Date: 25 Sept 98

1	**Substrate Type:**	**Beamsplitter**
2	**Serial Number:**	**BS05-B**
3	**Physical quantity certified:**	**Scratches and Point Defects**
4	**LIGO specification reference:**	**E960100-B-D**
5	**CSIRO measurement/inspection procedure reference:**	**HABA-LIGO-M-SP-A**
6	**Variations to the measurement/inspection procedure:** (indicate Yes/No and attach separate sheet if Yes)	**No**
7	**CSIRO Log Book Reference**	**LN00062**
8	**Team member responsible for measurement/inspection:**	**E Pavlovic**
9	**Measurement/inspection results reviewed by:**	**J Seckold**

10. Results

	Numbers of point defects		**Total Area of scratches (square micrometres)**	
	Inside central 80 mm	**Entire surface (235 mm)**	**Inside central 80 mm**	**Outside central 80 mm (235 mm)**
Surface 1	**Nil**	**Nil**	**Nil**	**< 50,000**
Surface 2	**Nil**	**Nil**	**Nil**	**< 25,000**

11. Certification

The measurements and inspection data presented in this report were obtained using the procedures outlined in the relevant CSIRO procedures document (sec. 5). These results have been reviewed against the LIGO specifications (sec. 4). Taking into account the variations (if any) from these measurement procedures noted in sec.6, CSIRO certifies the substrate to comply with the LIGO specification for this physical quantity.

Project Manager: Chris Walsh

Date: 25 Nov 98


Thin
2000
3000
2000
2000
2000
5000
5000
5000
5000
BS05
SIDE 1
8000
3000
5000

BSO 5
SIDE 2

1	**Substrate Type:**	**Beamsplitter**
2	**Serial Number:**	**BS05-B**
3	**Physical quantity certified:**	**Surface Figure**
4	**LIGO specification reference:**	**E960100-B-D**
5	**CSIRO measurement/inspection procedure reference:**	**HABA-LIGO-M-SF-A**
6	**Variations to the measurement/inspection procedure:** (indicate Yes/No and attach separate sheet if Yes)	**The measurement of wave front as per E960100-B-D has been replaced by a specification on the wave front transmitted through the substrate, and is calculated as a sum of the measurement on side 1 and the wave front measured as per E960100-B-D (refer CSIRO/Caltech fax correspondence)**
7	**CSIRO Log Book Reference**	**LLN/0137-01, p.86 - 87**
8	**Team member responsible for measurement/inspection:**	**J Seckold**
9	**Measurement/inspection results reviewed by:**	**B Oreb**

10. Results

	Radius of Curvature in km (Parabolic sag in nm)	**Astigmatism (nm)**	**Electronic data file reference**
Surface 1	**> 8,000 km (0.6 nm)**	**5.6**	**BS_51.zip**
Surface 2	**290 km (17.2 nm)**	**3.8**	**BS_52.zip**
Wave front*	**- 188 km (-26.6 nm)**		**BS_5T.zip**

*Measured as per the test procedure in E960100-B-D. Figure quoted and phase map are for the equivalent of a single pass.

Transmitted wave front (single pass): The parabolic sag equivalent to that of a wave front transmitted through the beam splitter can be found by adding the sag measured for surface 1 to that measured for the single pass-equivalent of a wave front double passing the material after reflection from side 1 (shown in the table above).

The combined sag is **-26 nm**, which lies within the tolerance band agreed with Caltech of 14 nm> Sag > -50 nm.

Hardcopies of the phase maps are attached to this certification as part of Attachment 1 for Side 1, Attachment 2A for Side 2 and Attachment 2B for the wave front measured as per E960100-B-D. The phase of the wave front shown in Attachment 2B is equivalent to a single pass measurement. Phase map data is stored in electronic format at the CSIRO ftp site under the filenames shown in the third column.

11. Certification

The measurements and inspection data presented in this report were obtained using the procedures outlined in the relevant CSIRO procedures document (sec. 5), modified during subsequent discussions and fax correspondence. These results have been reviewed against the LIGO specifications (sec. 4). Taking into account the variations (if any) from these measurement procedures noted in sec.6, CSIRO certifies the substrate to comply with the LIGO specification for this physical quantity.

Project Manager:  Chris Walsh

Date: 25 Sep 98

1	**Substrate Type:**	**Beamsplitter**
2	**Serial Number:**	**BS05-B**
3	**Physical quantity certified:**	**Surface Errors - Low Spatial Frequency**
4	**LIGO specification reference:**	**E960100-B-D**
5	**CSIRO measurement/inspection procedure reference:**	**HABA-LIGO-M-SL-A**
6	**Variations to the measurement/inspection procedure:** (indicate Yes/No and attach separate sheet if Yes)	**No**
7	**CSIRO Log Book Reference**	**LLN/0137-01, pp. 86-87**
8	**Team member responsible for measurement/inspection:**	**Jeff Seckold**
9	**Measurement/inspection results reviewed by:**	**B Oreb**

10. Results

	Low Frequency Surface Errors (nm)	
	80 mm aperture	**200 mm aperture**
Surface 1	1.2 nm	1.5 nm
Surface 2	1.1 nm	1.3 nm

Hardcopies of the phase maps over the central 200 mm with piston, tilt, power and astigmatism removed are enclosed with this certification in Attachment 1 for Side 1 and Attachment 2 for Side 2.

11. Certification

The measurements and inspection data presented in this report were obtained using the procedures outlined in the relevant CSIRO procedures document (sec. 5). These results have been reviewed against the LIGO specifications (sec. 4). Taking into account the variations (if any) from these measurement procedures noted in sec.6, CSIRO certifies the substrate to comply with the LIGO specification for this physical quantity.

Project Manager: Chris Walsh

Date: 25 May 98

1	**Substrate Type:**	**Beamsplitter**
2	**Serial Number:**	**BS05-B**
3	**Physical quantity certified:**	**Surface Errors - high spatial frequency**
4	**LIGO specification reference:**	**E960100-B-D**
5	**CSIRO measurement/inspection procedure reference:**	**HABA-LIGO-M-SH-A**
6	**Variations to the measurement/inspection procedure:** (indicate Yes/No and attach separate sheet if Yes)	**Data were analysed using PC-based software routines rather than HP-based routines.**
7	**CSIRO Log Book Reference**	**LLN/091**
8	**Team member responsible for measurement/inspection:**	**F Lesha**
9	**Measurement/inspection results reviewed by:**	**C Walsh**

10. Results

10.1 Surface errors in nanometres averaged over sampling locations within central 80 mm:

Side 1: **0.11 nm**

Side 2: **0.13 nm**

10.2 Surface errors in nanometres averaged over all sampling locations on surface:

Side 1: **0.13 nm**

Side 2: **0.13 nm**

10.3 Surface errors in nanometres at different positions A through H on surface:

	A	B	C	D	E	F	G	H
Surface 1	**0.10**	**0.12**	**0.10**	**0.14**	**0.09**	**0.14**	**0.12**	**0.16**
Surface 2	**0.14**	**0.13**	**0.13**	**0.11**	**0.11**	**0.12**	**0.14**	**0.16**

Two - dimensional surface maps at three central locations are available at the CSIRO ftp site under filenames of the form TMBS0YZA.asc, where M is the objective used (M=2 for 2.5X, 4 for 40X), BS is the substrate type, 0Y is the number, Z = 1 or 2 is the side and A = A, B, C, ... is the sampling position. Hard copies of the data are at Attachment 3 (Side 1) and Attachment 4 (Side 2).

11. Certification

The measurements and inspection data presented in this report were obtained using the procedures outlined in the relevant CSIRO procedures document (sec. 5). These results have been reviewed against the LIGO specifications (sec. 4). Taking into account the variations (if any) from these measurement procedures noted in sec.6, CSIRO certifies the substrate to comply with the LIGO specification for this physical quantity.

Project Manager:  Chris Walsh

Date: 25 Nov 98

LADI CERTIFICATION DATA

Title: BS_51.OPD

Date: 09/10/98

Diameter: 200 mm

Astig: 5.6 nm

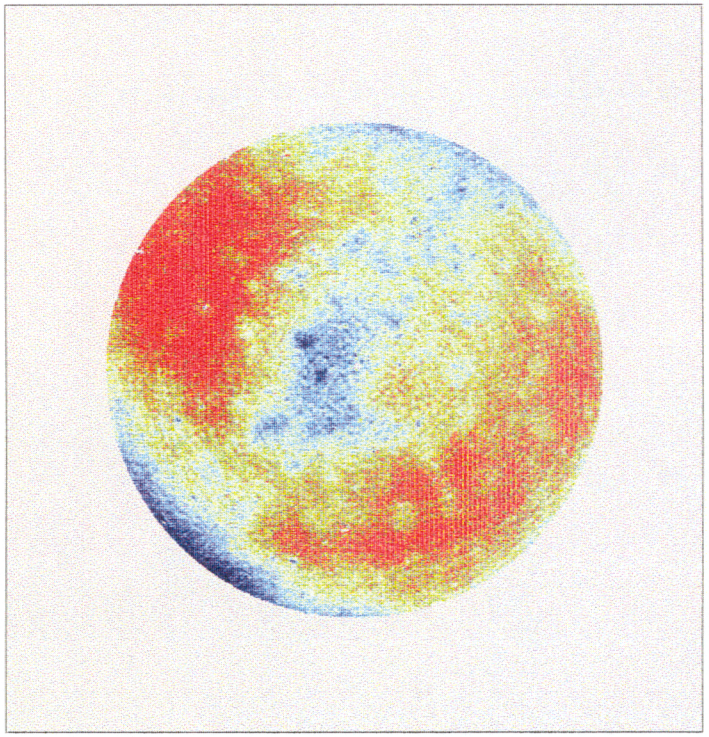
Power: 0.6 nm

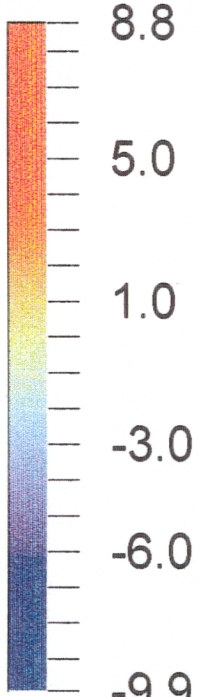
CSIRO

PV: 17.3 nm

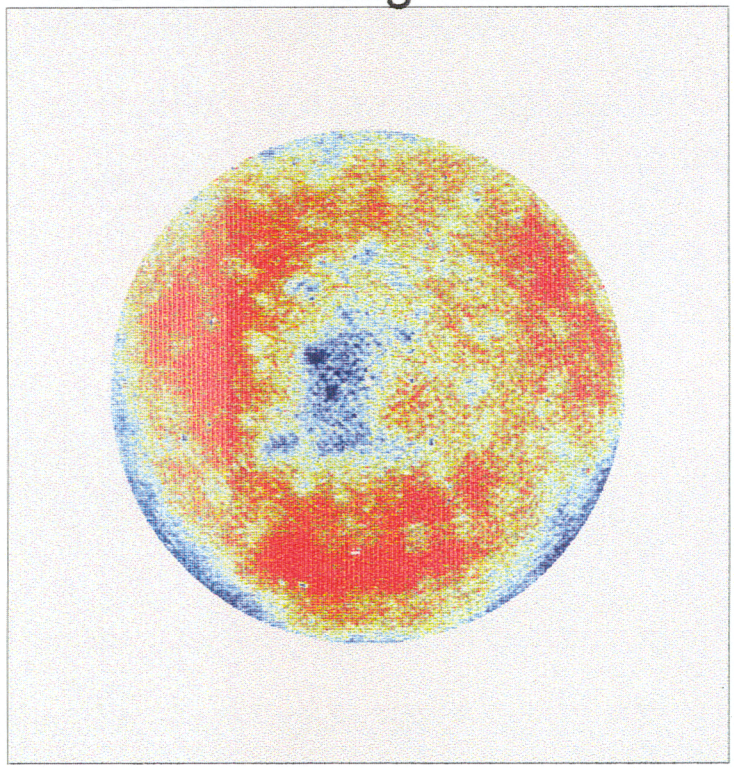
RMS: 1.5 nm

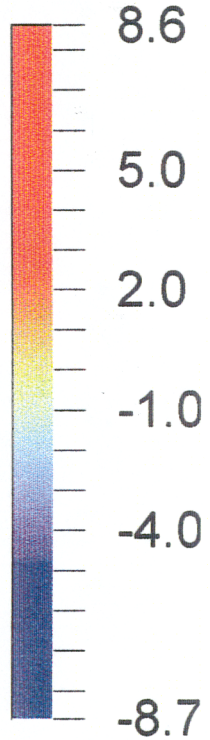
Tilt Removed





Tilt/Power/Astig Removed





LADI CERTIFICATION DATA

Title: BS_52.OPD

Date: 09/11/98

Diameter: 200 mm

Astig: 3.8 nm

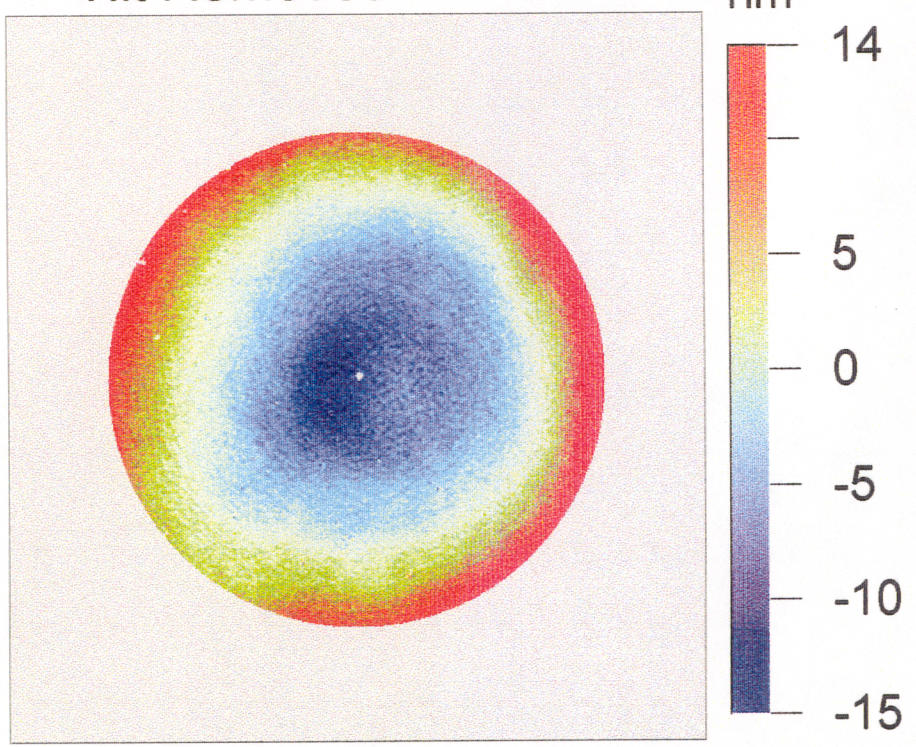
Power: 17.2 nm

CSIRO

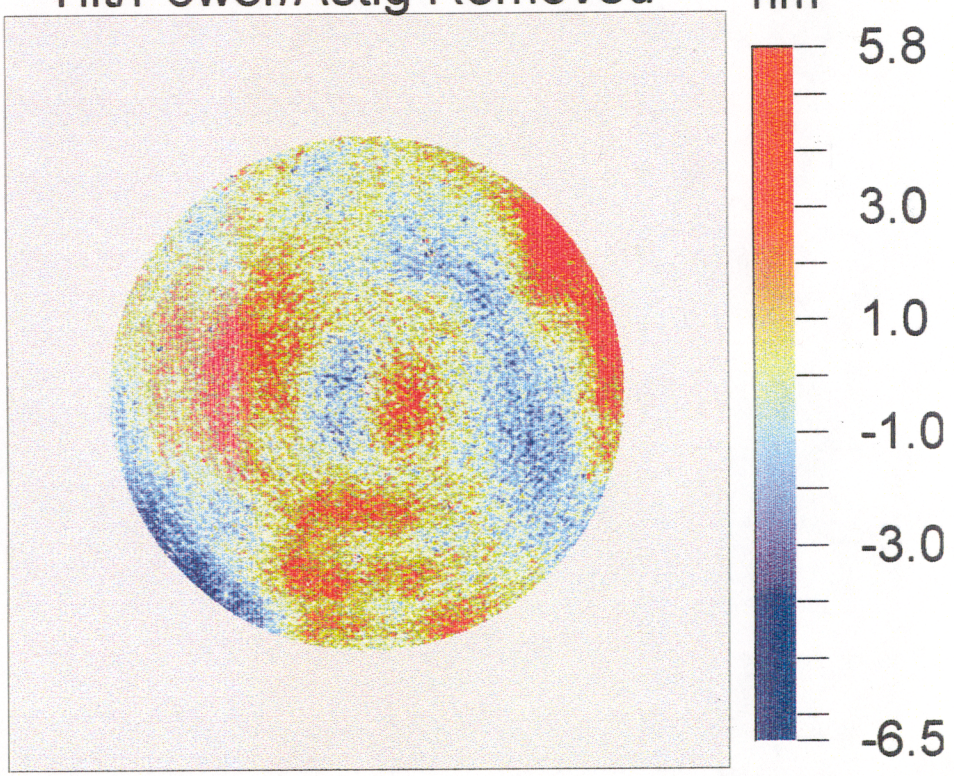
PV: 12.3 nm

RMS: 1.3 nm

Tilt Removed



Tilt/Power/Astig Removed



LADI CERTIFICATION DATA

Title: BS_5T.OPD

Date: 09/10/98

Diameter: 200 mm

Astig: -3.7 nm

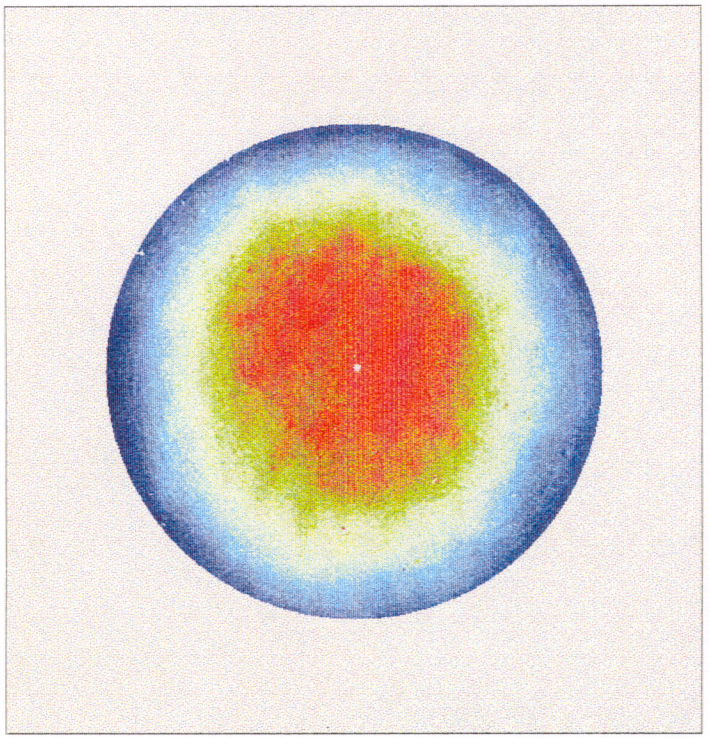
Power: -26.6 nm

CSIRO

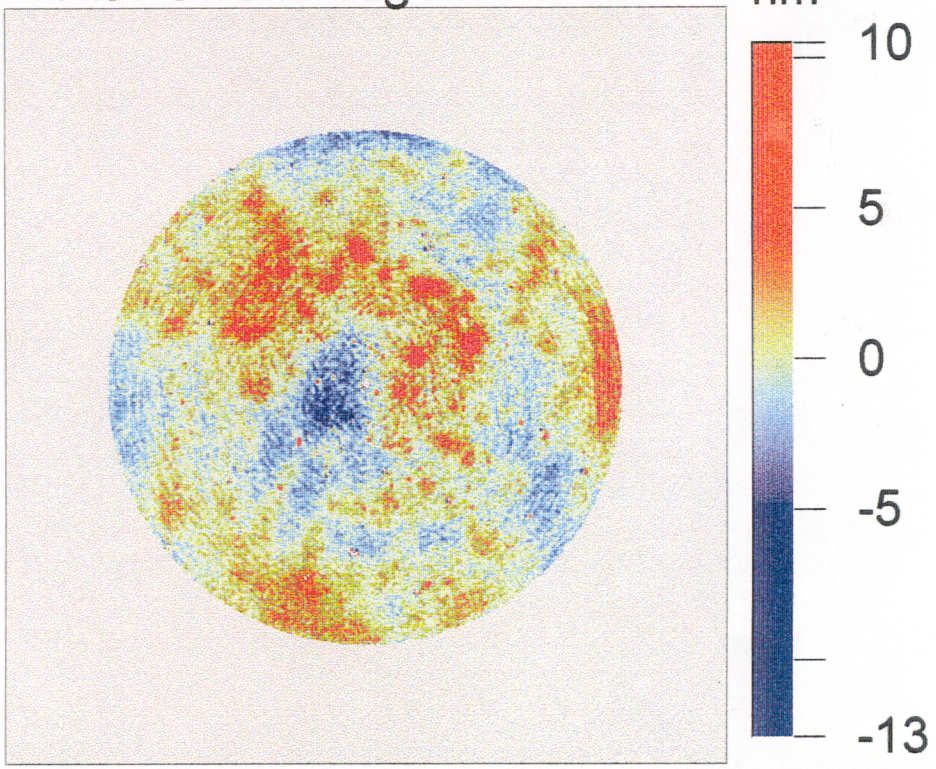
PV: 23.0 nm

RMS: 1.5 nm

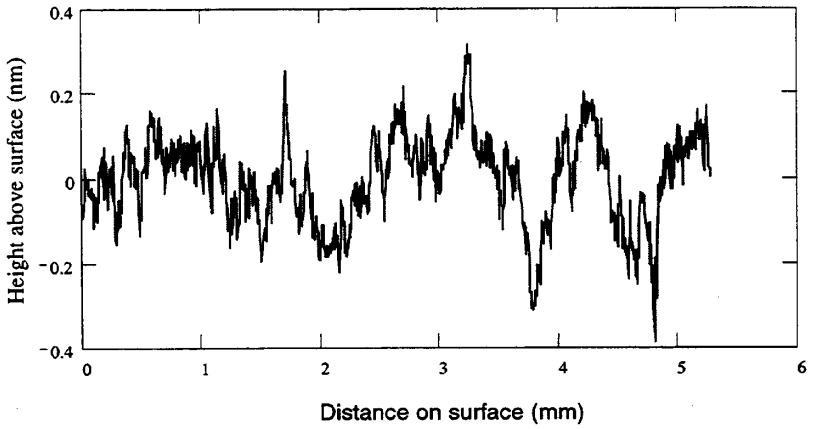
Tilt Removed



Tilt/Power/Astig Removed

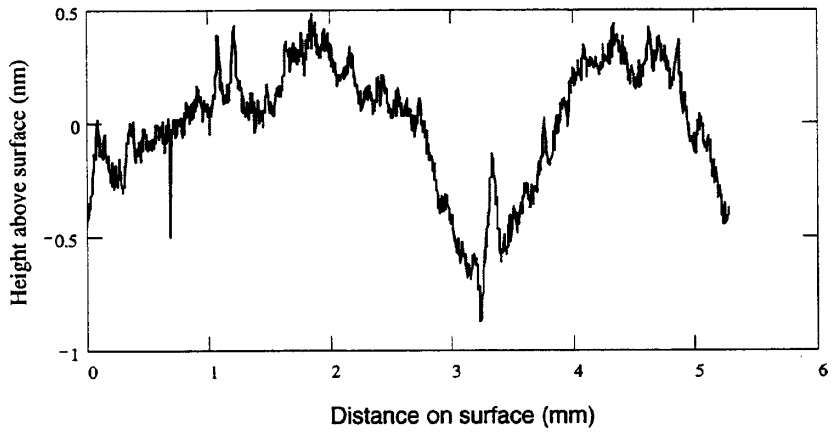


RMS = $1.05 \cdot 10^{-10}$ •m



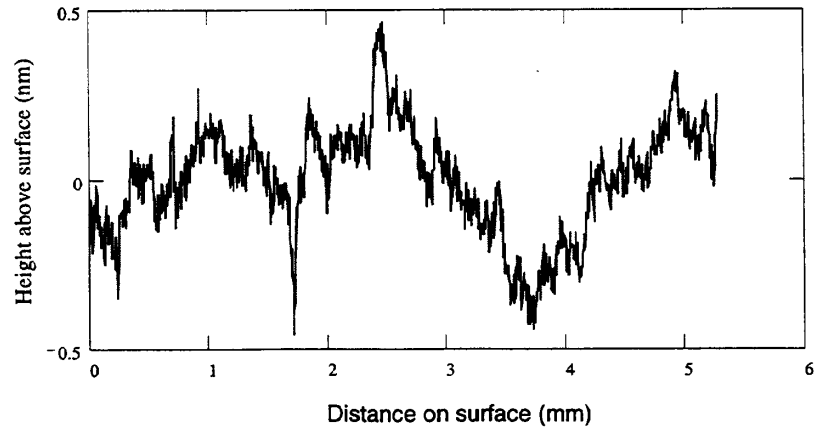
BS51A1

RMS = $2.72 \cdot 10^{-10}$ •m



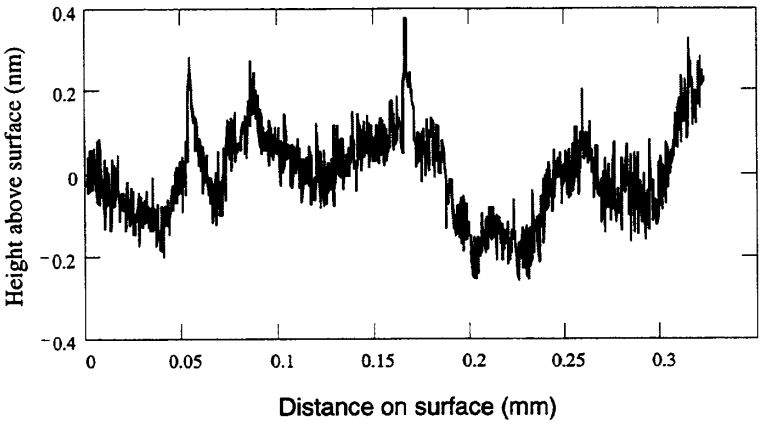
BS51B1

RMS = $1.605 \cdot 10^{-10}$ •m



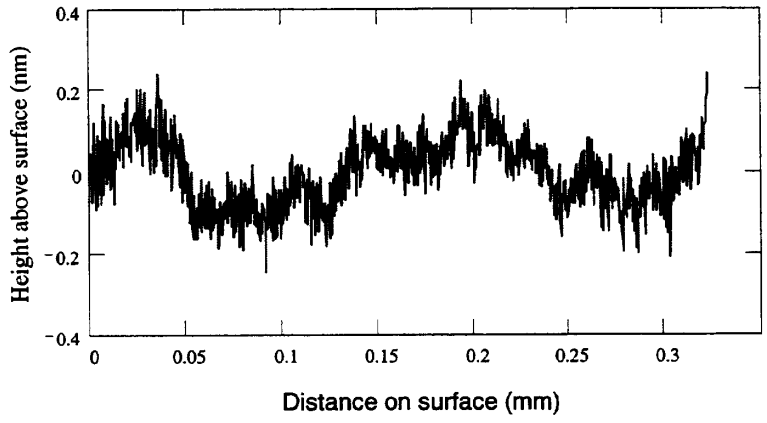
BS51C1

RMS = $1.092 \cdot 10^{-10}$ •m



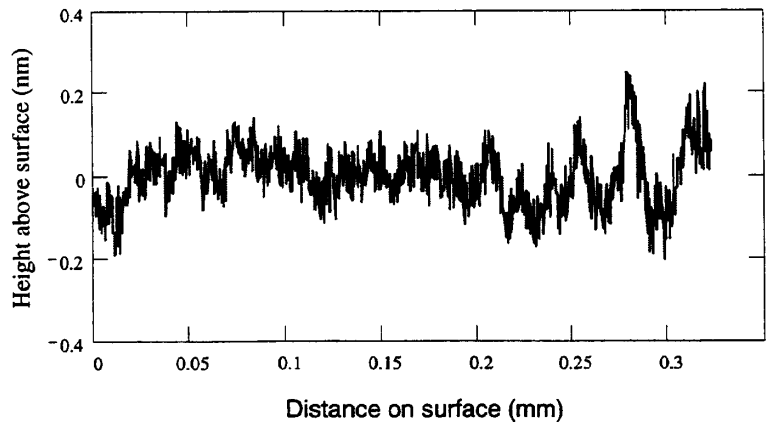
BS51A4

RMS = $8.522 \cdot 10^{-11}$ •m



BS51B4

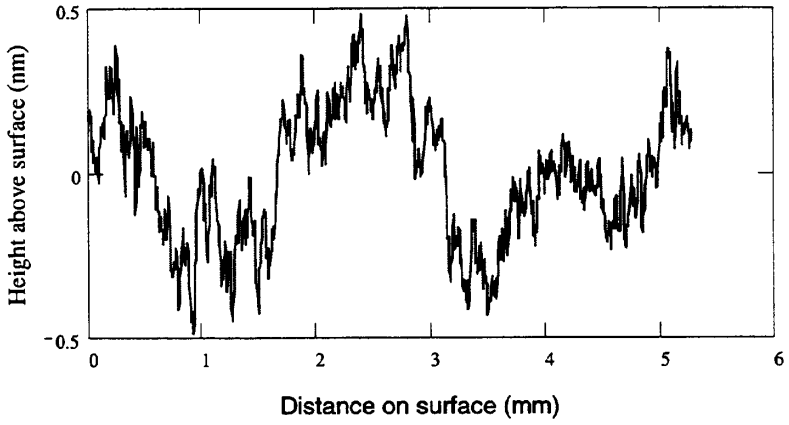
RMS = $7.091 \cdot 10^{-11}$ •m



BS51C5

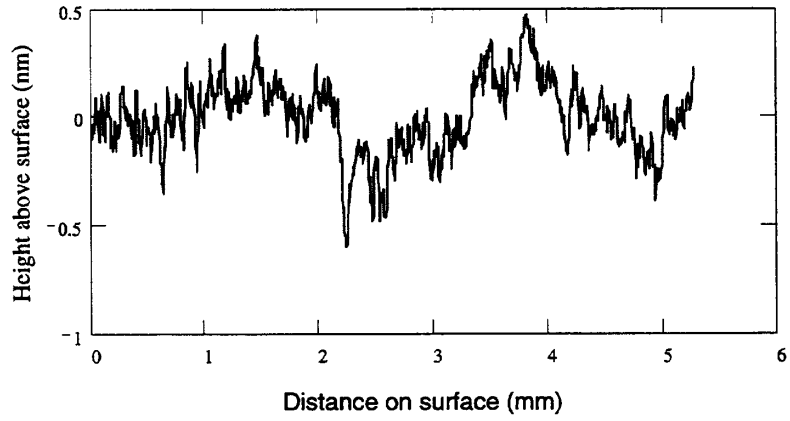
Attach. 4

RMS = $2.027 \cdot 10^{-10}$ •m



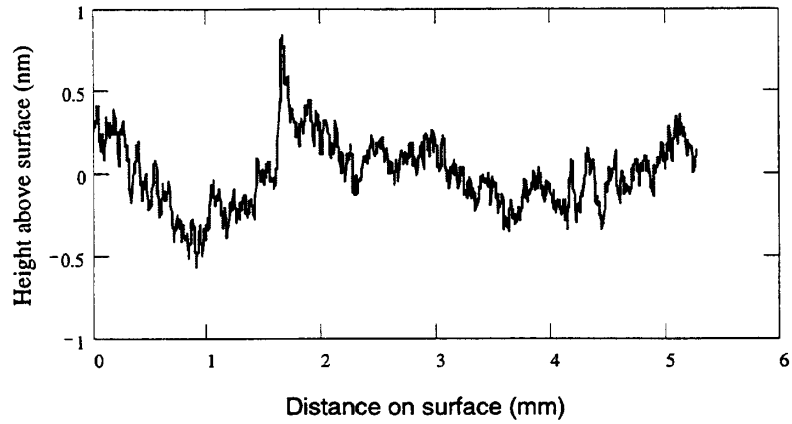
BS52A1

RMS = $1.703 \cdot 10^{-10}$ •m



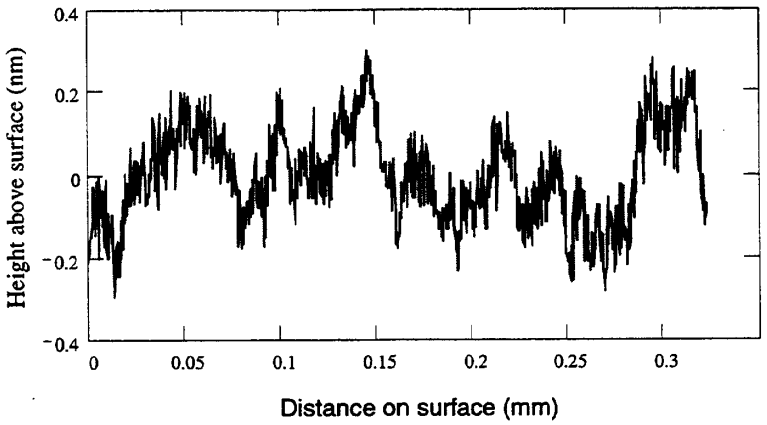
BS52B1

RMS = $2.068 \cdot 10^{-10}$ •m



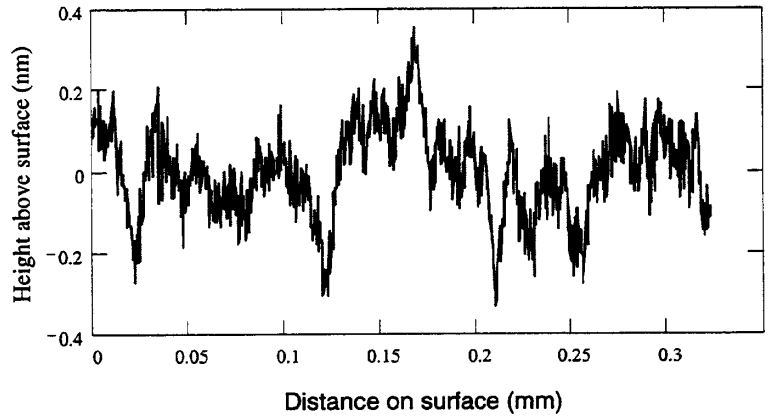
BS52C1

RMS = $1.157 \cdot 10^{-10}$ •m



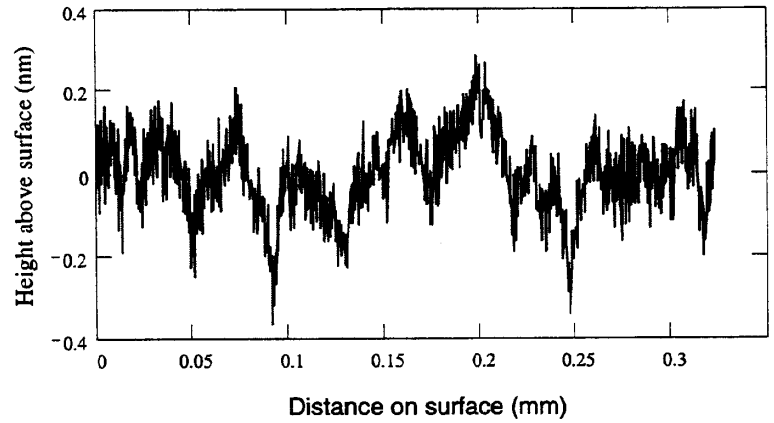
BS52A4

RMS = $1.093 \cdot 10^{-10}$ •m



BS52B4

RMS = $9.789 \cdot 10^{-11}$ •m



BS52C4

MIRROR

Research Electro-Optics Inc.

CERTIFICATE OF CONFORMANCE

Section3.14/REO QC Manual, Q-001, Doc. No. V:QA:REO 014, Rev."B", 09/13/96

Certificate of Conformance from: **Research Electro-Optics (REO) Inc.**
1855 South 57th. Court
Boulder, Colorado 80301
(303) 938-1960, Fax (303) 447-3279

Research Electro-Optics (REO), Inc. hereby certifies that the items listed below have been inspected and tested to the extent necessary to conform with all the requirements of the noted Purchase Order, drawing, and applicable specification(s). Inspection and test data are on file at our facility and will be furnished to customer upon request.

- Date of shipment : 27 Oct 98
- Customer Name, Purchase Order No. : LIGO
- Customer Part Number & Revision : E980069-00-D
- Part Description : Beamsplitter
- REO Job No. : OPT0583I-30 Run No.: S1: 0X843 S2: 0X844
- Qty. Shipped/Lot No. : 1 ea BS05
  2 ea 1" FS witness pieces

☒ **Test data (included)**

Comment:

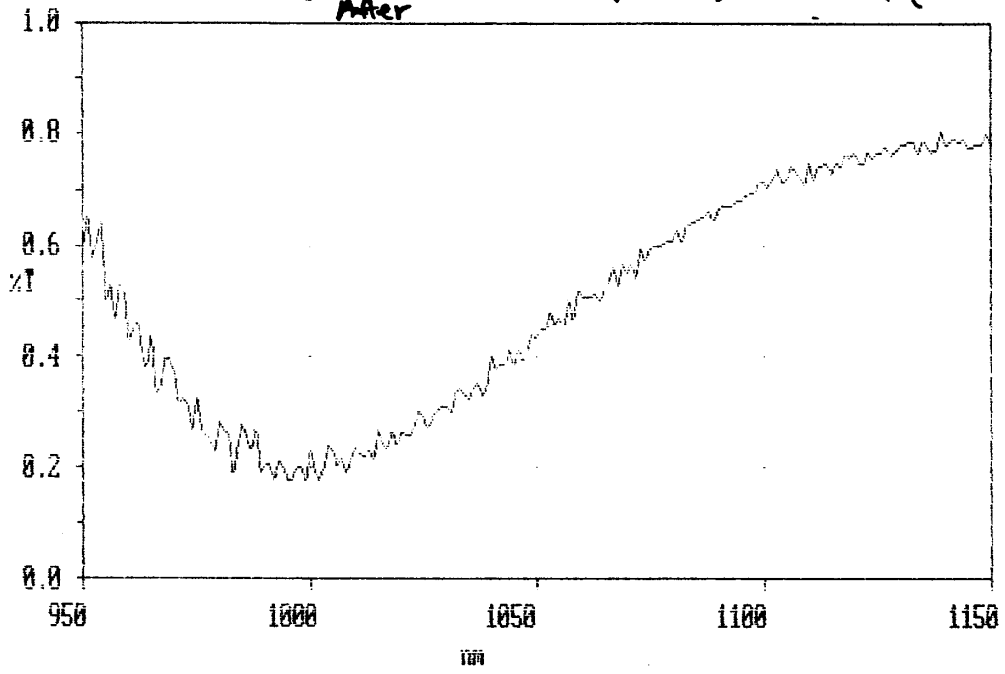
Certified by: Dale C Ness 27 Oct 98
Quality Assurance

Verified by: Ying Lu 10/27/98
Engr/Tech

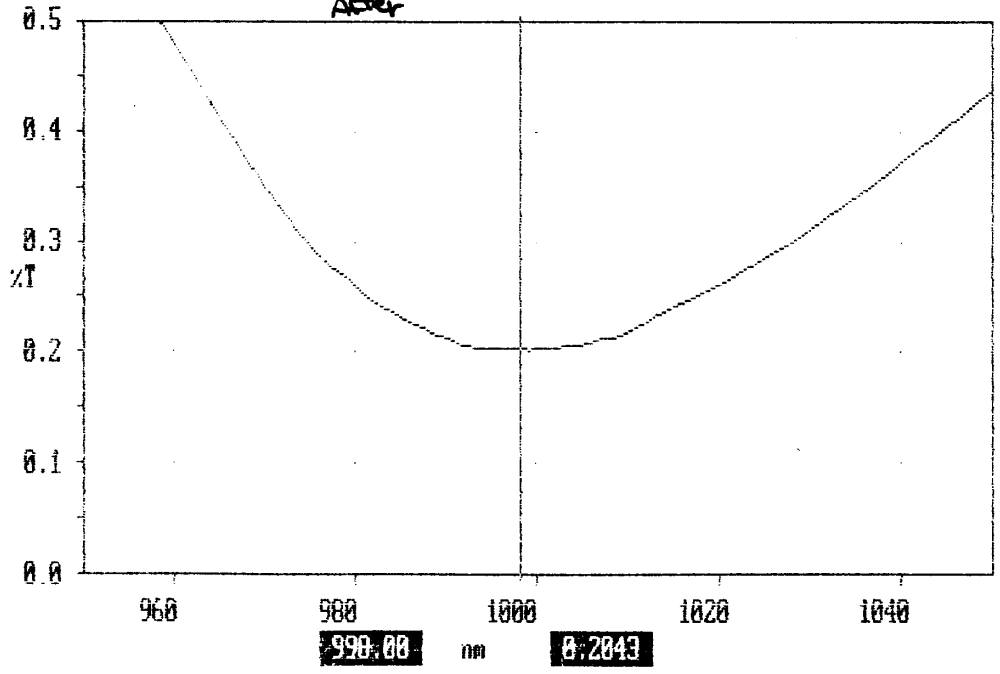
NOTE
Certificate must accompany the package to be shipped or attached to the outside of the same box to which the "Packing Slip" envelope is attached.

BSØ5

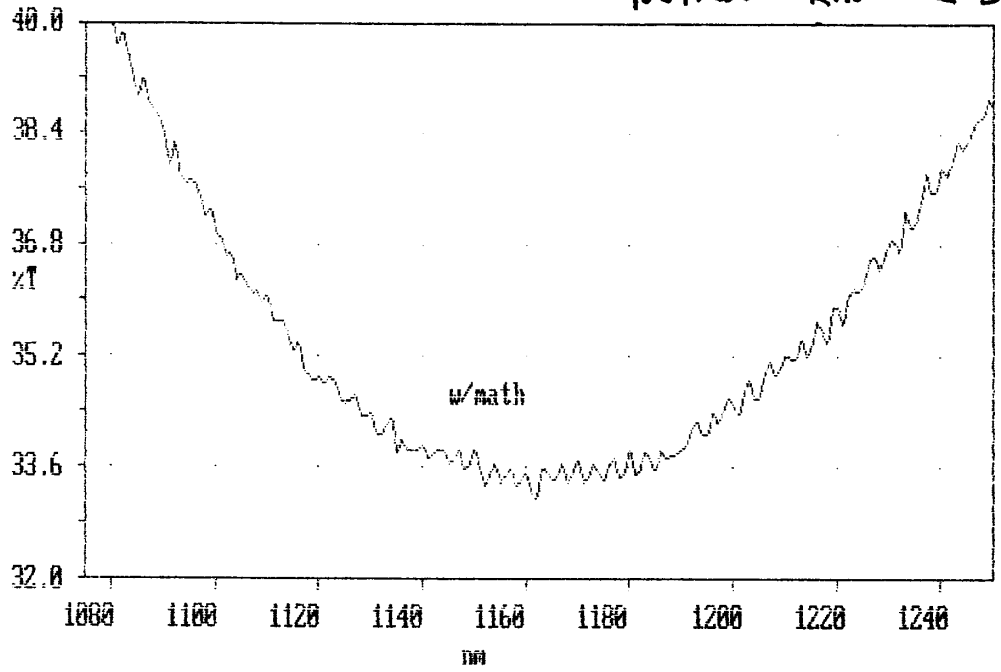
X: user001: 1150.0 - 950.0 nm; pts 201; int 1.00; ord 0.1736 - 0.8083 %T
Inf: ox844 AR@1064nm @45deg ~~before~~ After bake. Normal Incidence Scan



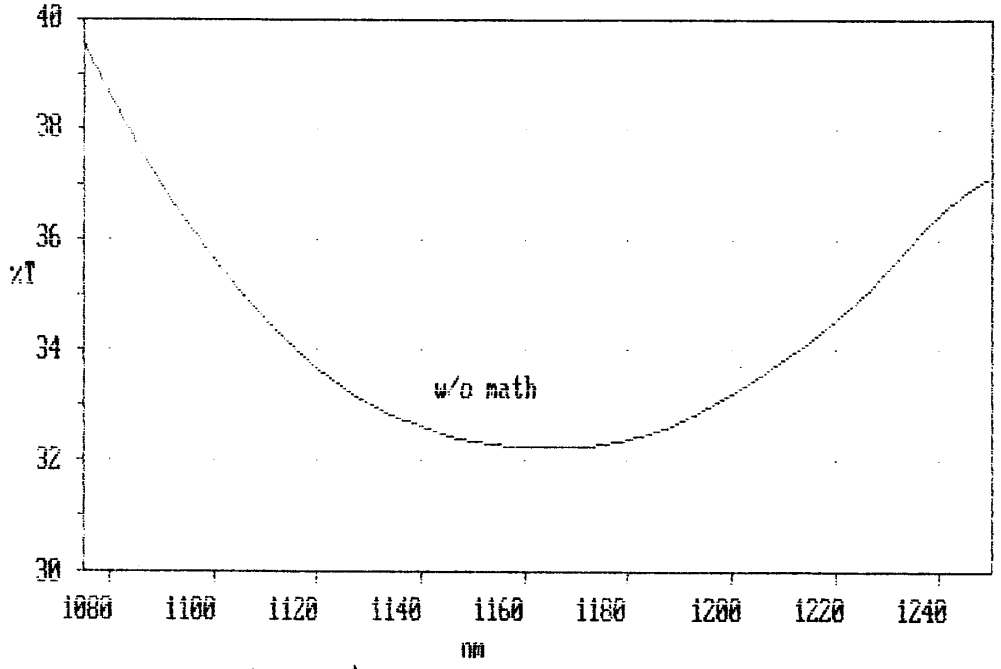
X: user001: 1150.0 - 950.0 nm; pts 201; int 1.00; ord 0.2032 - 0.7878 %T
Inf: ox844 AR@1064nm @45deg ~~before~~ After bake.



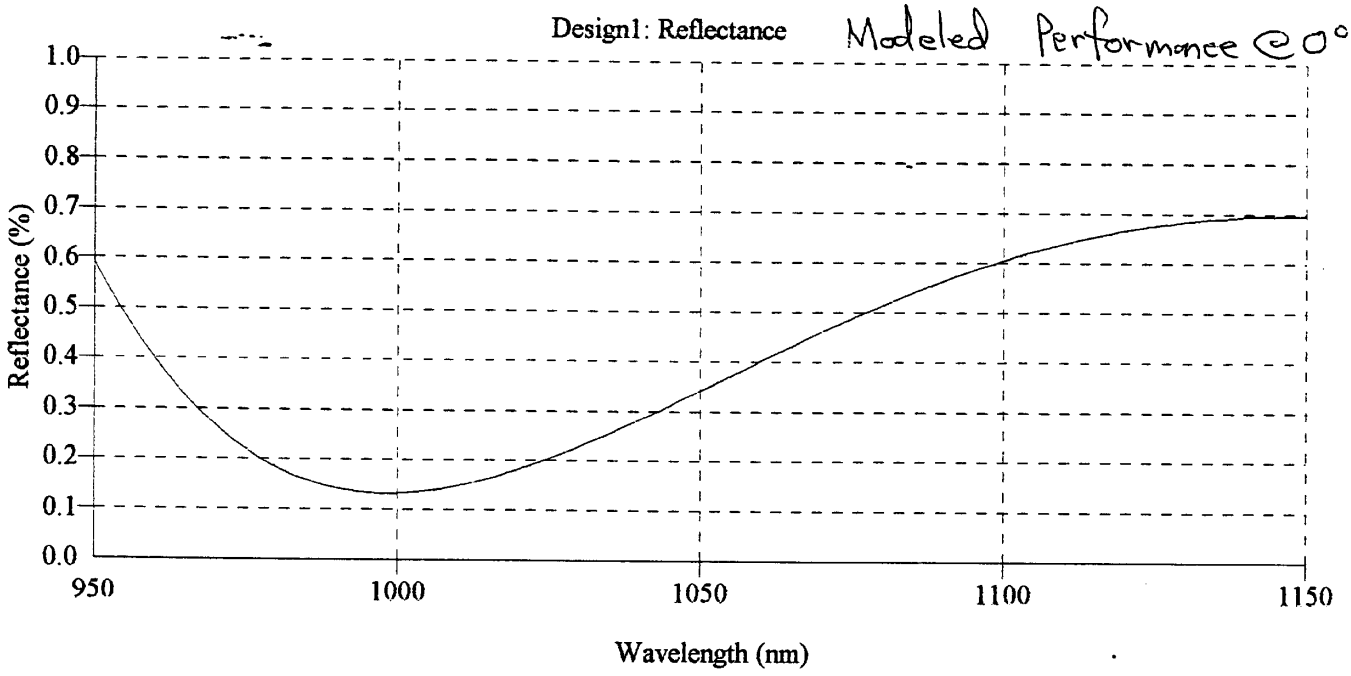
X: user001: 1250.0 - 900.0 nm; pts 351; int 1.00; ord 33.154 - 98.970 %T
Inf: ox843 HR@1064NM, @45DEG AFTER PROCESSING. Normal Incidence Scan.

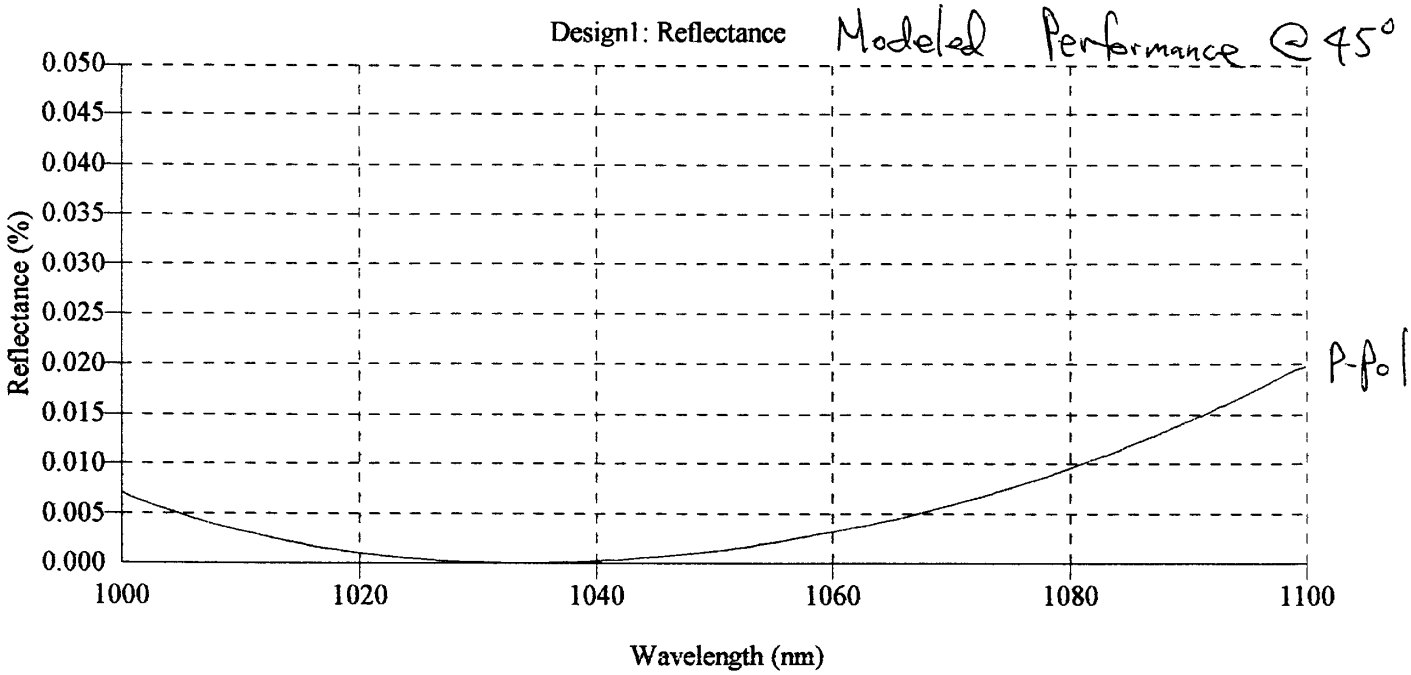


X: user001: 1250.0 - 900.0 nm; pts 351; int 1.00; ord 32.252 - 94.940 %T
Inf: ox843 HR@1064NM, @45DEG AFTER PROCESSING.



Measured with Laser @ 1064 nm
@45°, P-Pol. R = 50% ± 0.5%


Design1: Reflectance
Modeled Performance @ 0°
Reflectance (%)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
950
1000
1050
1100
1150
Wavelength (nm)


Design1: Reflectance
Modeled Performance @ 45°
Reflectance (%)
0.050
0.045
0.040
0.035
0.030
0.025
0.020
0.015
0.010
0.005
0.000
1000
1020
1040
1060
1080
1100
Wavelength (nm)
P-Pol

Research Electro-Optics Inc.
1855 South 57th Court, Boulder, Colorado 80301 (303) 938-1960 FAX (303) 447-3279

ORDER NO: OPT05831
SHIPMENT NO: 006073
PAGE: 1
DATE: 10/28/1998
CUST PO NUMBER: **PC162519/CON05**

P A C K I N G L I S T

SOLD TO:2040A
CALIFORNIA INST. OF TECHNOLOGY
I PETRAC, M/C: 18-34 LIGO
51-33 EAST BRIDGE LABORATORY
PASADENA, CA 91125

SHIP TO:000007
CALIFORNIA INST. OF TECHNOLOGY
51-33 EAST BRIDGE LAB, LIGO
ATTN: HELENA ARMANDULA, 18-34
PASADENA, CA 91125

SHIP VIA:FED-EX P1 COL

MISC #1:
MISC #2:

FOB: FACTORY TERMS: .0% - 0 DAYS; .0% - 0 DAYS; NET: 30 DAYS
TOTAL: PIECES: 1 WEIGHT: 85 LBS VOLUME: 0 CU FT

LN#	ITEM/CATALOG ITEM	UM	ORDER QUANTITY	QUANTITY DUE	SHIPPED QUANTITY	BACKORDER QUANTITY

THIS ORDER IS A CHANGE ORDER TO REO JOB# OPT04124.

PER QUOTES OPQ-2403 & OPQ-2472

REFERENCE: CALTECH LIGO-C98-00D/LIGO-C980963-00-D
LIGO-C950494-05-1

Technical Contact:
Helena Armadula Tel: 626-395-2070
Mail Code 18-34

Contractual Representative:
Irena Petrac Tel: 626-395-2975
Mail Code 18-34

Items #001 thru' #014 is per PO# PC162519 Change Order 5

Items #015 thru' #039 is per PO# PC162519 Change Order 6
Per REO quote #OPQ-2537. No Item #027 on this order
acknowledgment.

030	LIGOE980069	EA	1	0	1	0

BEAM SPLITTER, COATED
PER PART #BS, SPEC #LIGO-E980069-00-D.

BS05

Received complete

PACKED BY: CHECKED BY: DATE: