BS02-B

LIGO-T990135-00-D

BLANK

A. DCN: LIGO-T970201-00-D LIGO DETECTOR OPTICS
B. LIGO S/N: BS Ø2 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.: PC208421
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 8921
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. Inclusion map not 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. Not 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 direct 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.

~~Thickness out of spec~~. OK (EE)

OH not reported

S/N marked incorrectly - wrong serial number

SKETCHES:

DISPOSITIONS:

12-30-97 Received additional data package and OH-content report.

LIGO Component Specification Verification Sheet
Mirror Blanks, Beam Splitter

Mirror Blanks, Beam Splitter		Serial Number: BSØ2	Specification	Reported Value	✓
	Requirements	**Physical Dimensions**	LIGO-D960793-B	?	
		Diameter	256mm +1.0mm, -0mm	256.7mm	✓
		Thickness	52 ~~61~~mm +1.0mm, -0mm	52.84mm	✓*
		Chamfer	2.0mm Max 2pl	—	-
		Clear Aperture	Central 235mm	—	
		Material	Fused Silica Suprasil #~~3000~~ 311S	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.	
		Homogeneity Within the Central 150mm	$\leq 5.0 \times 10^{-7}$ p – v $\lambda = 632.8$nm	Interferogram Homogeneity Map	✓
		Homogeneity Within the Central 225mm	$\leq 2.5 \times 10^{-6}$ p - v $\lambda = 632.8$nm	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.	No
		Absorption	2ppm/cm $\lambda = 1.06$nm	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 8921
Marking	: 960095-IM 14 -B502 BN 5057

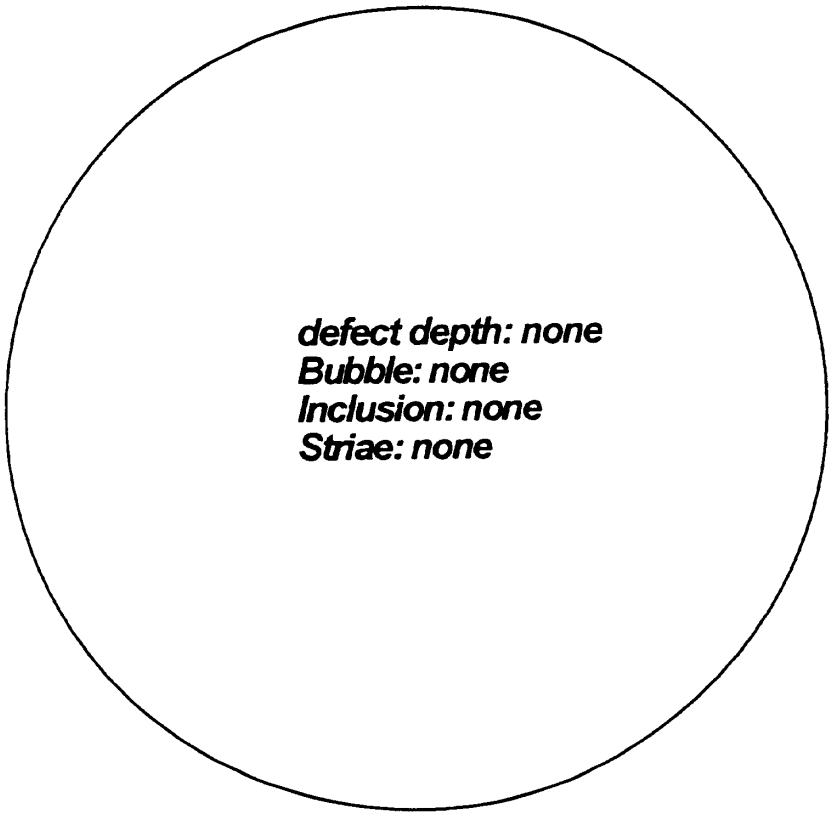
Diameter		: 256,7mm
CA Diameter		: Ø 200 mm = 0,71xE^{-6}
Thickness		: 52,84 mm
Edge		: 0,3 - 0,5 mm
Parallelism		: 0,08 mm
Roughness		: ground
	R_a	: 1,08 µm
	R_t	: 8,86 µm
Bubble class		: 0 ; none bubbles
Birefringence		: CA Ø200 mm <= 5nm/cm;
Homogeneity		: see Interferogram
Striae Grade		: A
Granularity		: 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 Ø 256,7 mm x 52.84 mm Quality: Suprasil 311 Plate No.: 960095-IM 14/ 5057	Date: 6.10.97 Inspector:

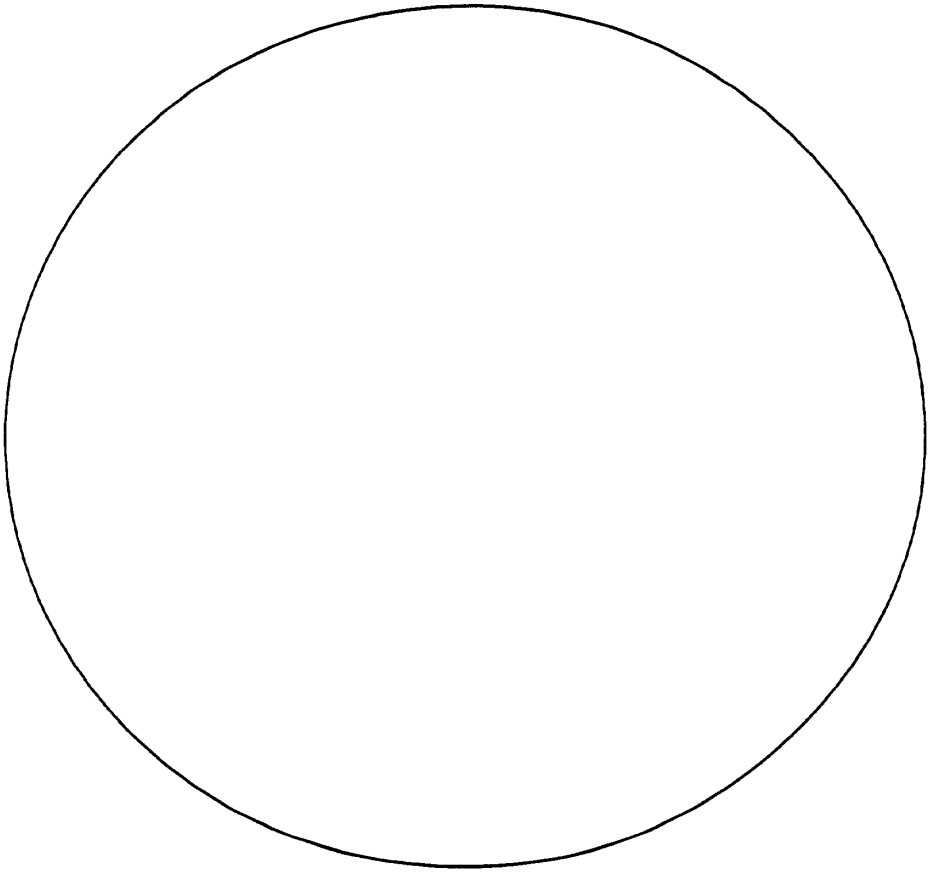


Diameter	0,03mm	0,05mm	0,08mm	0,12mm	0,2mm	0,31mm	Sum
piece							
mm^2							

TBCS= mm^2 /100cm^3

g:\groups\pol\pol-qw\amipro\form\pro_Bub3.sam

Heraeus QUARZGLAS POL - QW	Order No.: 94908401 Pos.: 2 Ø 256,7 mm x 52,84 mm Plate No.: 960095-1414/5057 Residual strain- Report	Date: 6.10.97 Inspector:

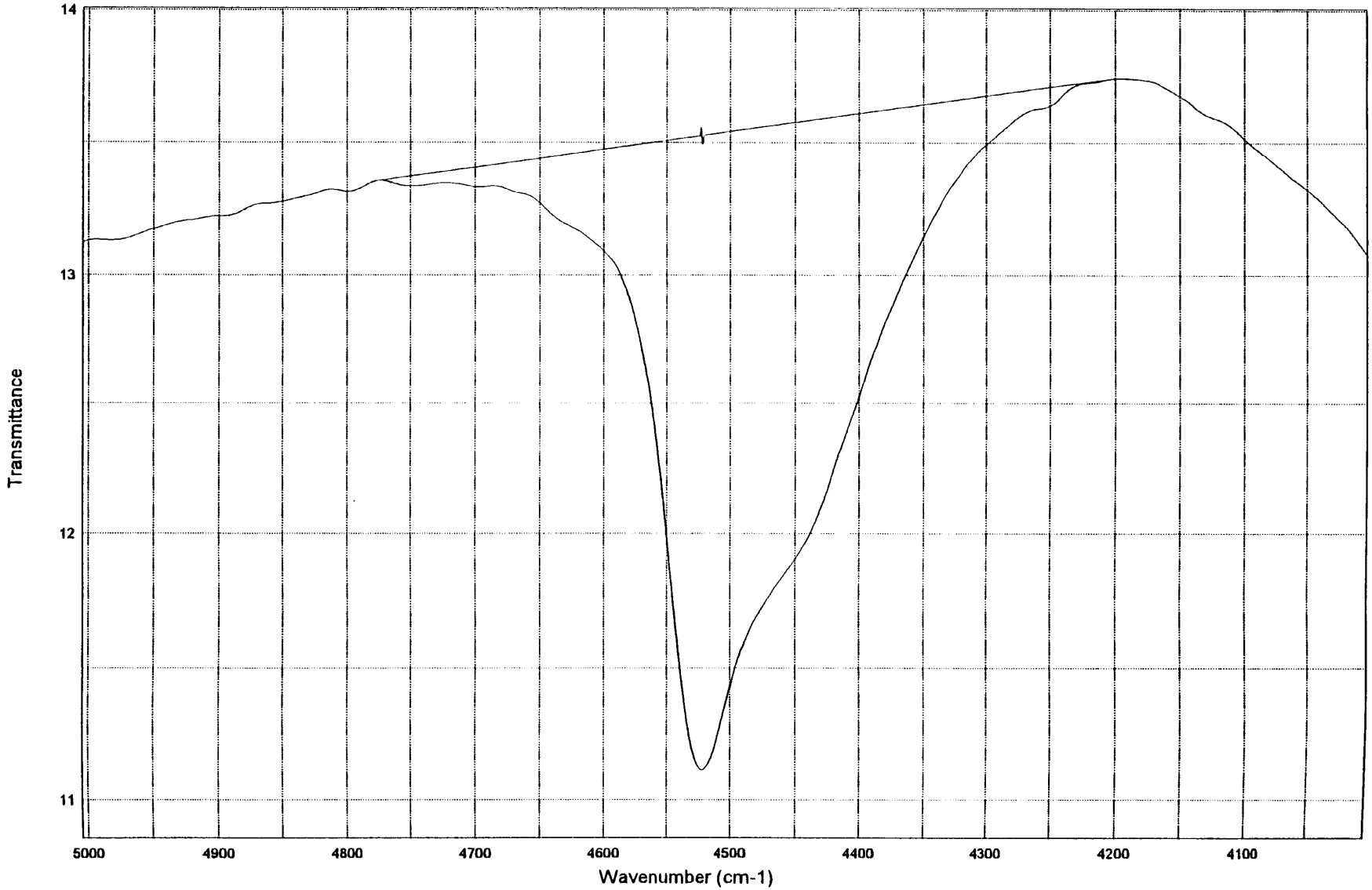


Edge	Center						Pos.
10							nm
2	< 1						nm/cm

I0=13.5271 , I1=11.1148 at x=4522 OH-content: 142.2 ppm

Heraeus
QUARZGLAS

MEASURE NO. : 5057
DATE : 05.09.1997 TIME : 12:20
MEASURE START : 10000 1/cm
MEASURE END : 2500 1/cm
OP-DISK-PATH LENGTH : Ko-203-PL: 2.64 cm / Order No.: 9930 3974 / Material: 5057-----OH-content: 142.2 ppm at x=4522



Heraeus
QUARZGLAS

POL-QW

Data taken at 632.8 nm

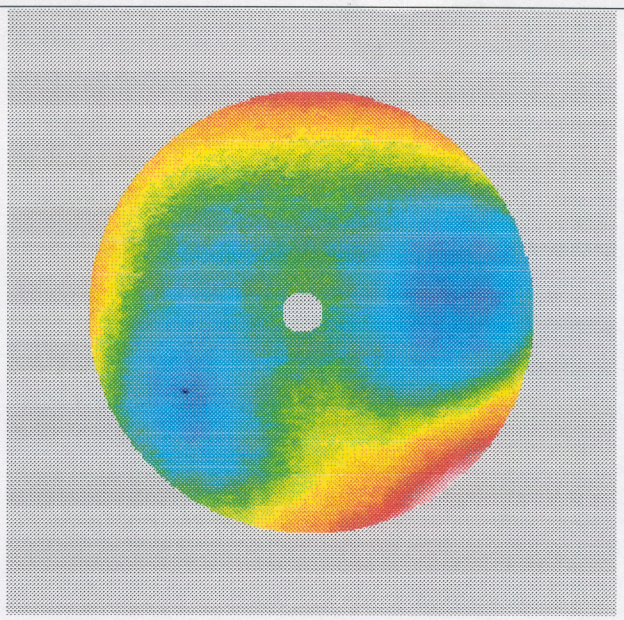
Date: 04.09.97
ID: 505700

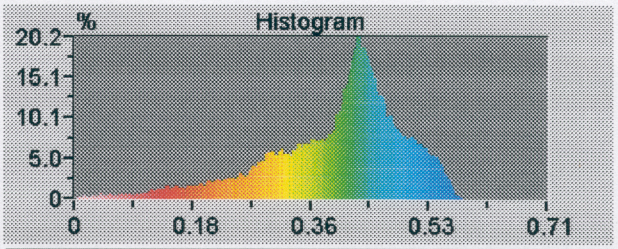
Operator: Rt
No.:

HQS-Order-No.: 98492874
Customer: HAI
Product: LIGO
Pos.-No.: 2
Order-No.:
Comment: 960094-im-xx

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





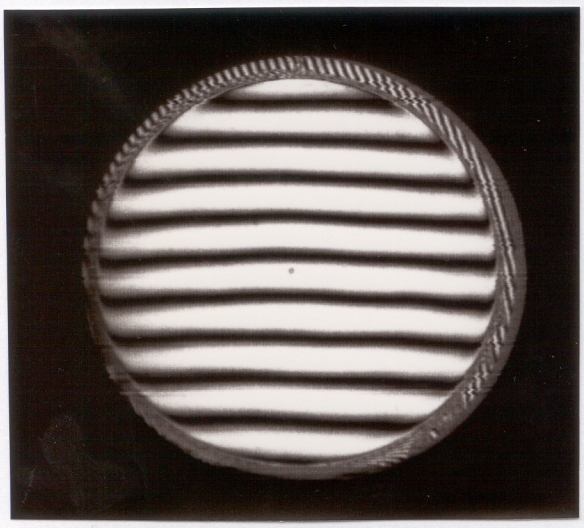
Sub. Terms		Magn.	Angle
X	Tilt	0.0556	-117.1828
	Focus	-0.0885	
	Astigm.	0.1663	-69.7358
	Coma	0.0212	29.3450
	SA3	-0.0616	

Phase Data
Unit n(ppm)
PV: 0.71
RMS: 0.100
Scale: 0.5

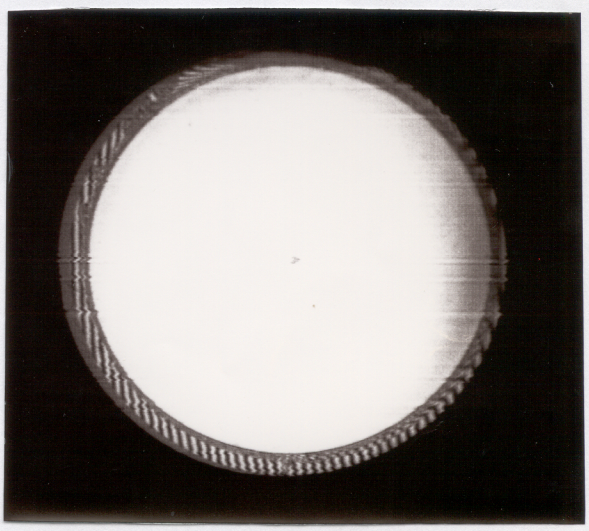
Contrast

Reset
UpperL 0.713
LowerL 0.000

File: 505700.tif, 04.09.97, 16:32
XPS-12"



BSØ2



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

30117

JM

SUBSTRATE

A. DCN: LIGO-T970201-01-D **LIGO DETECTOR OPTICS**
B. LIGO S/N: BS02-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.: _____ D. Substrate Polisher: CSIRO

E. Core optic Material: (BS) FM / 2ITM / 4ITM / ETM / RM F. Date Received: 10-02-98

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	39.96	mm
☑	Wedge Angle 1° 0′					

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. ~~No shipper~~ (5)

Inspection By: Steve Gibson Date Inspected: 07-06-98

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.)

~~Shipper was not on transit case.~~ Rec'd.

SKETCHES:

See vendor sketches (scratches S1 & S2)

DISPOSITIONS:

Substrate, Beam Splitter	Serial Number: BSØ2-B		Specification	Reported Value	✓
	Surface 1	Surface Figure Over Central 200mm dia.	Flat		
		Radius of Curvature	> 200 km convex > 720 km concave	-804 Km	✓
		Astigmatism	< 16nm p-v	-4.1 nm	✓
	Surface 2	Surface Figure Over Central 200mm dia.	Nominally Flat		
		Radius of Curvature of the Wavefront	> 140 km convex > 500 km concave	344 Km	✓
		Astigmatism	< 23nm p-v	4.2 nm	
	Surface Errors	Low Spatial Frequency Band Central 80mm	$\leq 4.3\ cm^{-1}$ $\sigma_{rms} < 1.6nm$	0.5 nm	✓
		Low Spatial Frequency Band Central 200mm	$\leq 4.3\ cm^{-1}$ $\sigma_{rms} < 3.2nm$	0.7 nm	✓
		High Spatial Frequency Band Central 80 & 200 mm	$\leq 4.3 - 7{,}500\ cm^{-1}$ $\sigma_{rms} < 0.4nm$	0.2 0.2	✓

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). S1 20K	Hand Sketch w/dimensions	✓
		The total area of scratches outside the central 80 mm diameter shall not exceed 750 x 10^3 square micrometers. S2 35K	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

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 : 28 July 98
- Customer Name, Purchase Order No. : LIGO ; PO # PC162519/C0005/0006
- Customer Part Number & Revision : Ligo - E980064 - 00 - D
- Part Description : Beam Splitter
- REO Job No. : OPT05831-021 Run No.: 1R (beam splitter - 0X750 - 0X782)
- Qty. Shipped/Lot No. : 1 ea - B501 1 ea - 1" FS witness
  1 ea - B502

☒ Test data (included)

Comment:

Certified by: _____, 7/28/98
Quality Assurance

Verified by: Dale C Nestel, 28/July/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.

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

Serial number: BS02-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:	BS2B1.zip	(Side 1)	BS2B2.zip	(Side 2)
			BS2B2A.zip	(wave front)
TOPO data: (2.5X)	T2BS21A.asc	(Side 1)	T2BS22A.asc	(Side 2)
	T2BS21B.asc		T2BS22B.asc	
	T2BS21C.asc		T2BS22C.asc	
(40X)	T4BS21A.asc		T4BS22A.asc	
	T4BS21B.asc		T4BS22B.asc	
	T4BS21B.asc		T4BS22C.asc	

1	**Substrate Type:**	**Beamsplitter**
2	**Serial Number:**	**BS02-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**
8	**Team member responsible for measurement/inspection:**	**C Sona**
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)	 39.96mm
Bevel as per drawing (height, angle):	(S1) Height: 2.25 mm Angle:$45^0$15' (S2) Height: 2.18 mm Angle:$44^0$29'
Wedge angle:	$1^0$0'
Location of registration mark ($\pm$ angle with respect to minimum part thickness):	+1'
Location of other 3 marks (with respect to registration mark at minimum thickness)	$90^0$0', $180^0$0', $270^0$1'
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: 19 June 98

1	**Substrate Type:**	**Beamsplitter**
2	**Serial Number:**	**BS02-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:**	**E 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: CWalsh Chris Walsh

Date: 19 June 98

1	**Substrate Type:**	**Beamsplitter**
2	**Serial Number:**	**BS02-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:**	

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: 19 June 98

1	**Substrate Type:**	**Beamsplitter**
2	**Serial Number:**	**BS02-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:**	**C Walsh**

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**	**20,000**	**nil**
Surface 2	**nil**	**nil**	**nil**	**35,000**

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: 19 June 98


BSO2
SIDE 1

H

Thin

BSO2

SIDE 2

11

11

11

1	**Substrate Type:**	**Beamsplitter**
2	**Serial Number:**	**BS02-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 pp 19-20**
8	**Team member responsible for measurement/inspection:**	**D Farrant**
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	**-804 km (-6.0 nm)**	**-4.1**	BS2B1.zip
Surface 2	**344 km (14.5 nm)**	**4.2**	BS2B2.zip
Wave front*	**>7000 km (0.7 nm)**		BS2B2A.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 0.7 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: 19 June 98

LADI CERTIFICATION DATA

CSIRO

Title: BS_21

Date: 05/30/98

Diameter: 200 mm

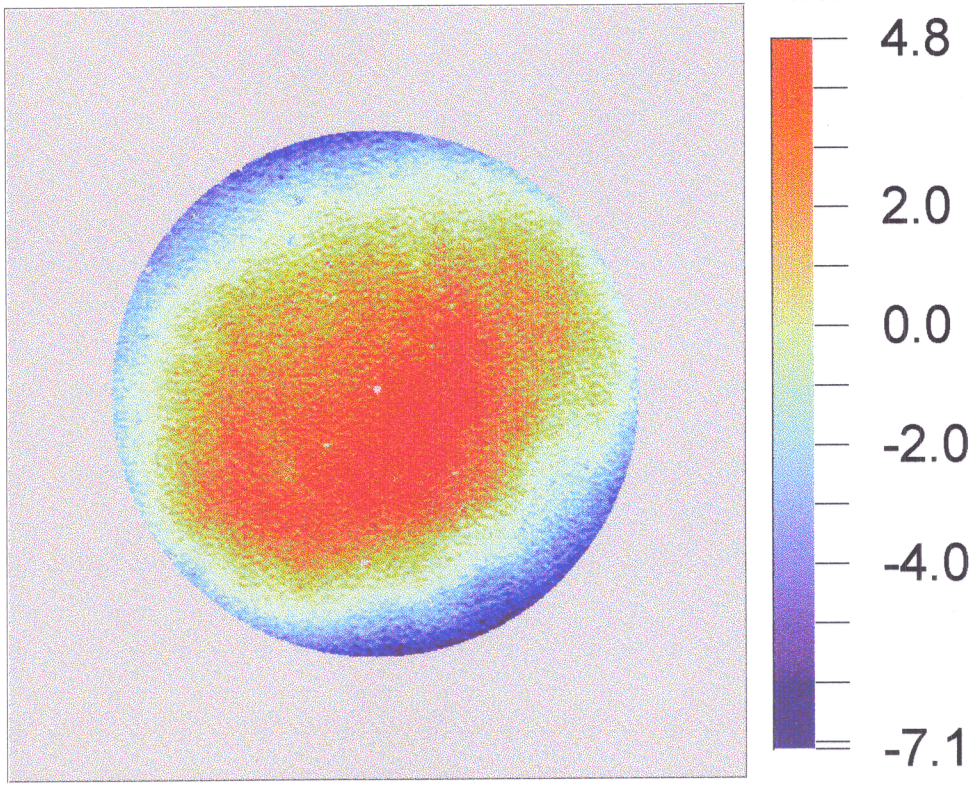
Astig: -4.1 nm

Power: -6.0 nm

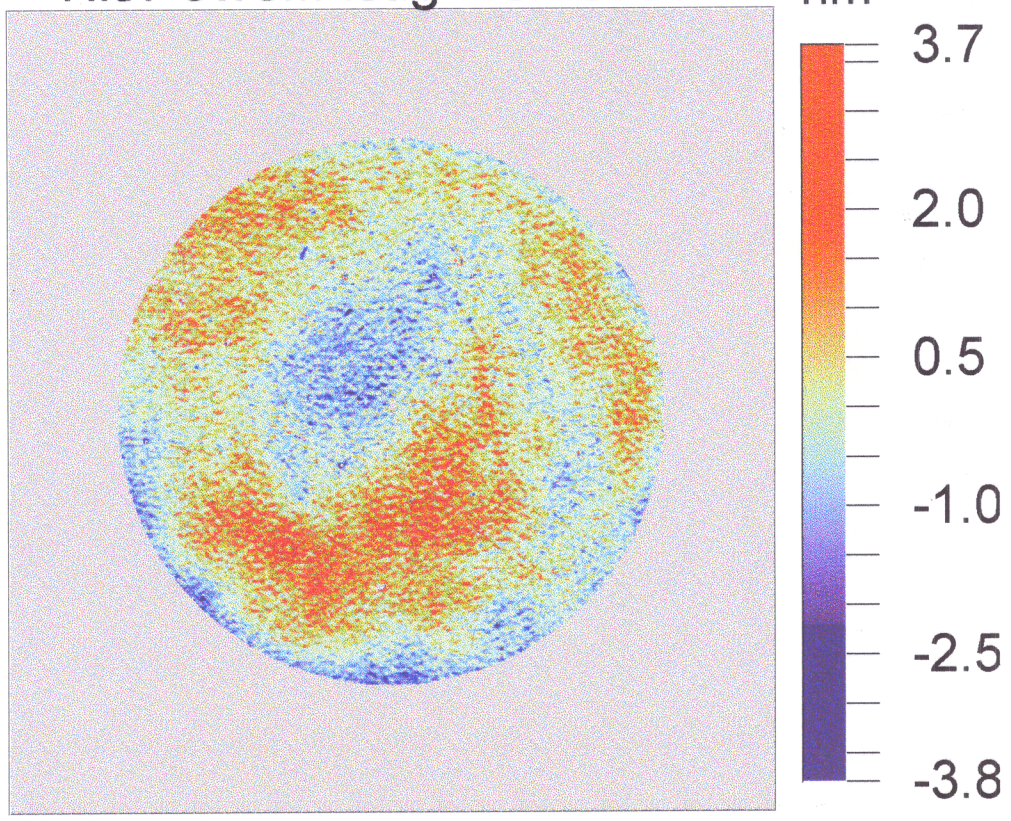
PV: 7.5 nm

RMS: 0.6 nm

Tilt Removed



Tilt/Power/Astig Removed



Att. 1

LADI CERTIFICATION DATA

CSIRO

Title: BS_22

Date: 05/30/98

Diameter: 200 mm

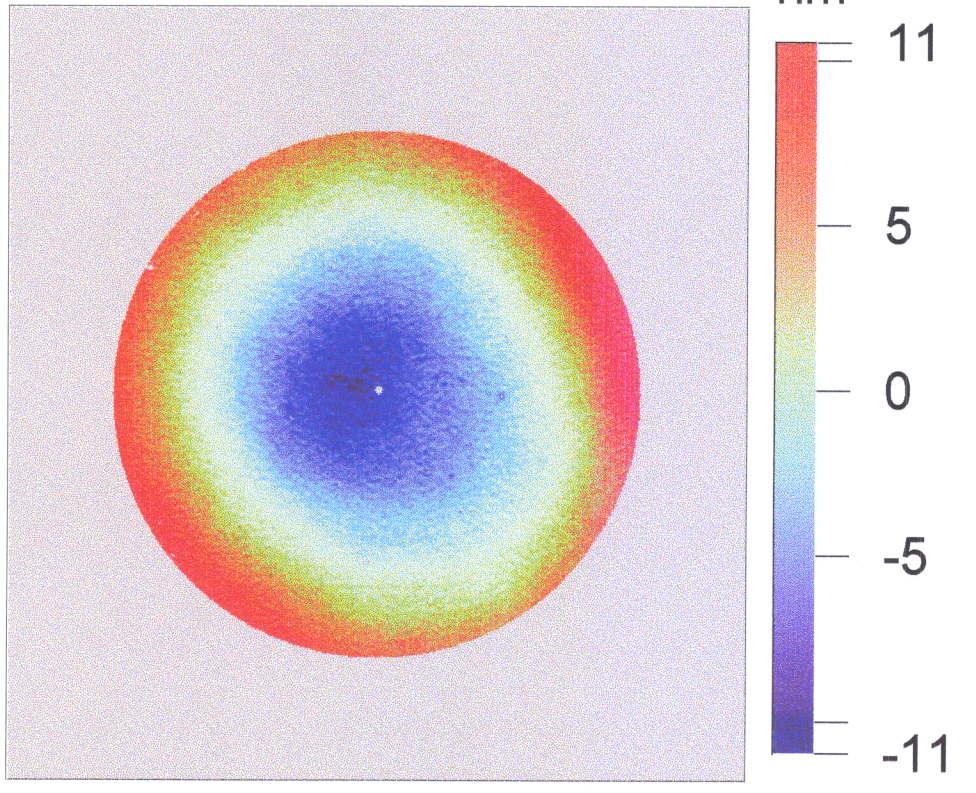
Astig: 4.2 nm

Power: 14.5 nm

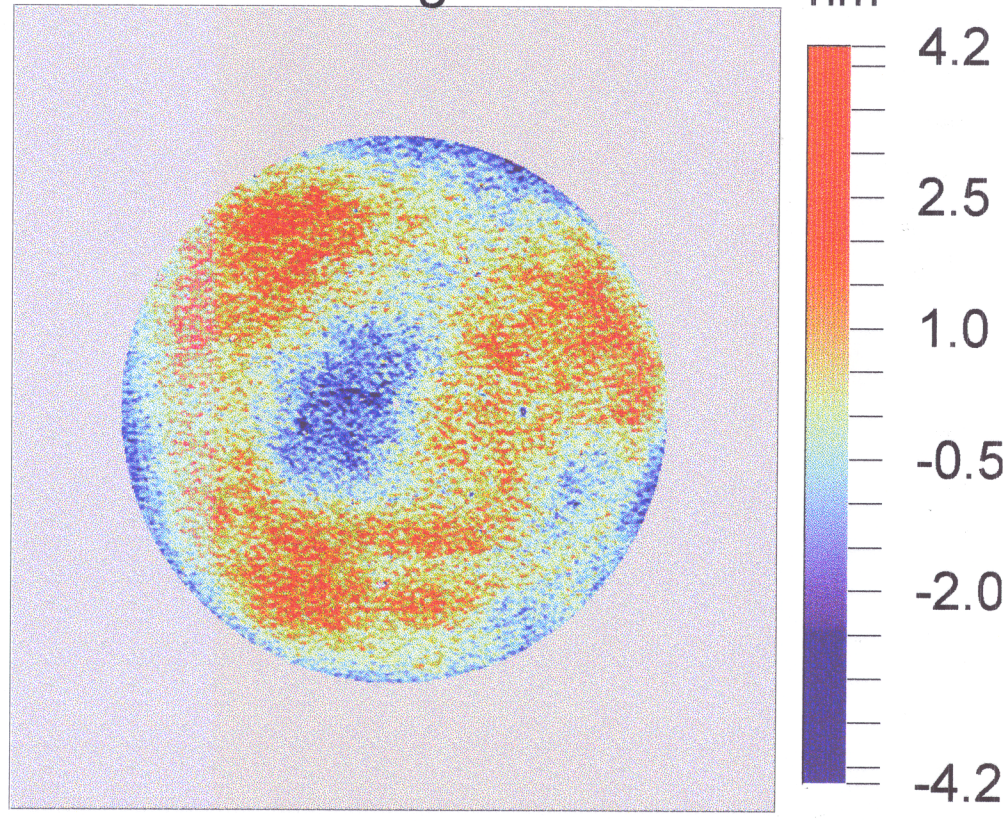
PV: 8.4 nm

RMS: 0.8 nm

Tilt Removed



Tilt/Power/Astig Removed



AH. 2R

LADI CERTIFICATION DATA

CSIRO

Title: BS_2T

Date: 05/30/98

Diameter: 200 mm

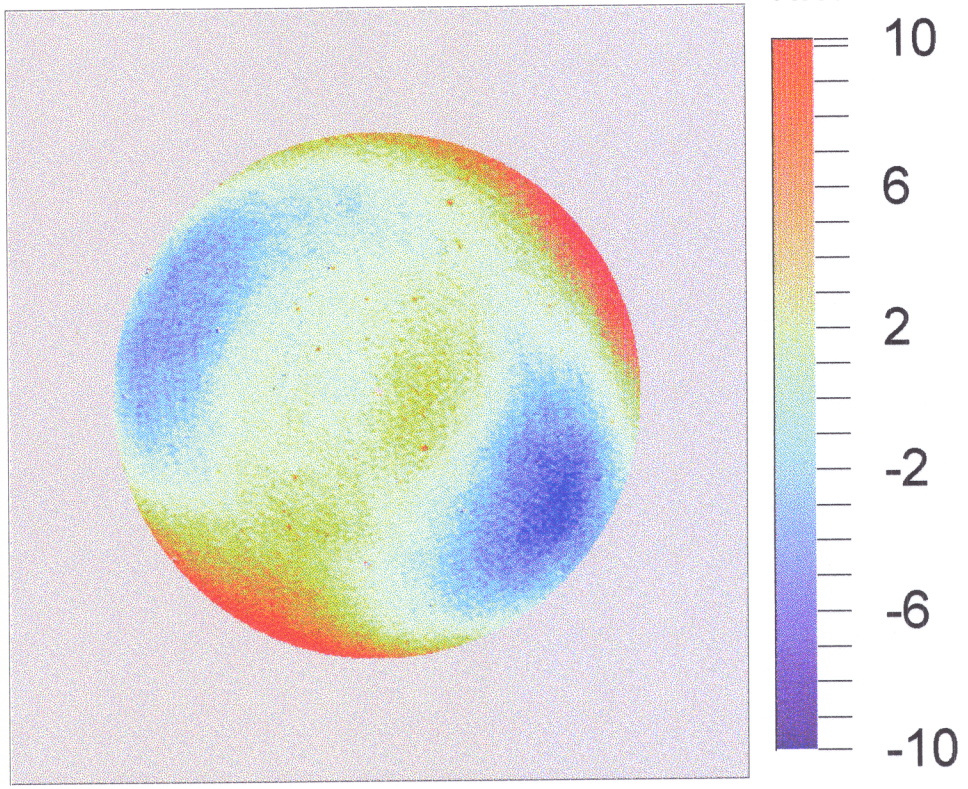
Astig: 11.9 nm

Power: 0.7 nm

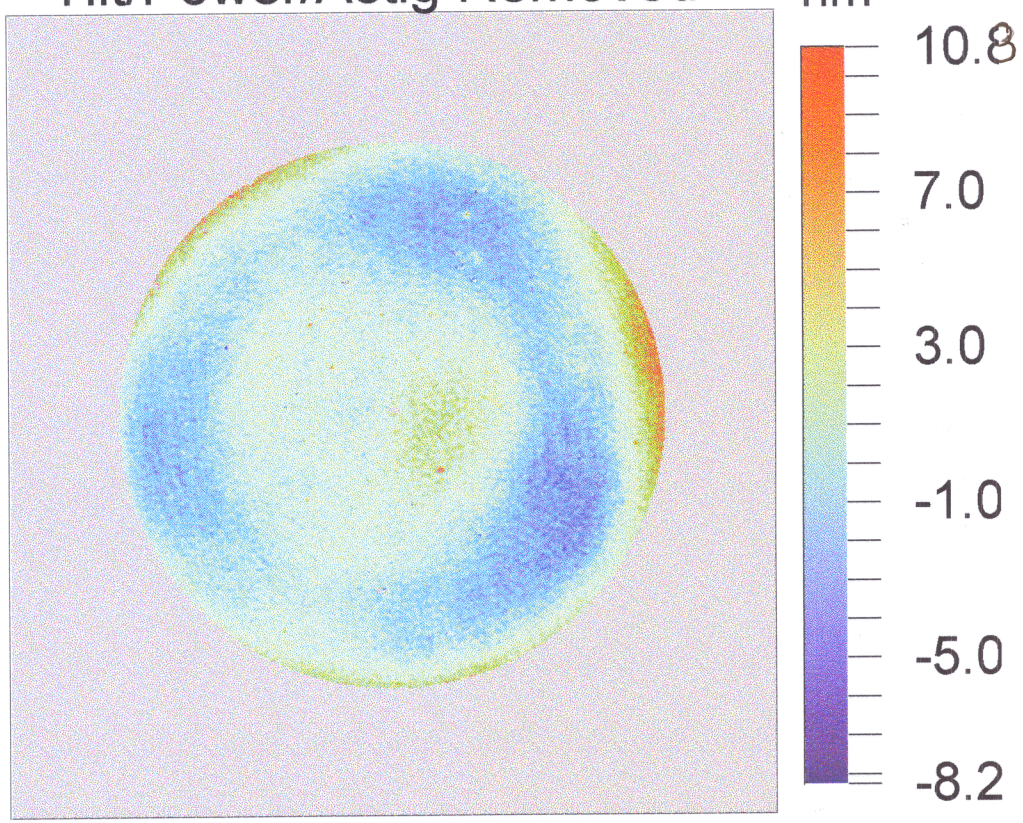
PV: 19.0 nm

RMS: 1.8 nm

Tilt Removed



Tilt/Power/Astig Removed



AH. 2B

1	**Substrate Type:**	**Beamsplitter**
2	**Serial Number:**	**BS02-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 19-20**
8	**Team member responsible for measurement/inspection:**	**D Farrant**
9	**Measurement/inspection results reviewed by:**	**B Oreb**

10. Results

	Low Frequency Surface Errors (nm)	
	80 mm aperture	**200 mm aperture**
Surface 1	0.5	0.7
Surface 2	0.6	0.8

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: 19 June 98

1	**Substrate Type:**	**Beamsplitter**
2	**Serial Number:**	**BS02-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: **0.20**

Side 2: **0.19**

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

Side 1: **0.20**

Side 2: **0.18**

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

	A	B	C	D	E	F	G	H
Surface 1	**0.20**	**0.18**	**0.20**	**0.19**	**0.20**	**0.20**	**0.20**	**0.21**
Surface 2	**0.20**	**0.19**	**0.17**	**0.20**	**0.18**	**0.16**	**0.16**	**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).

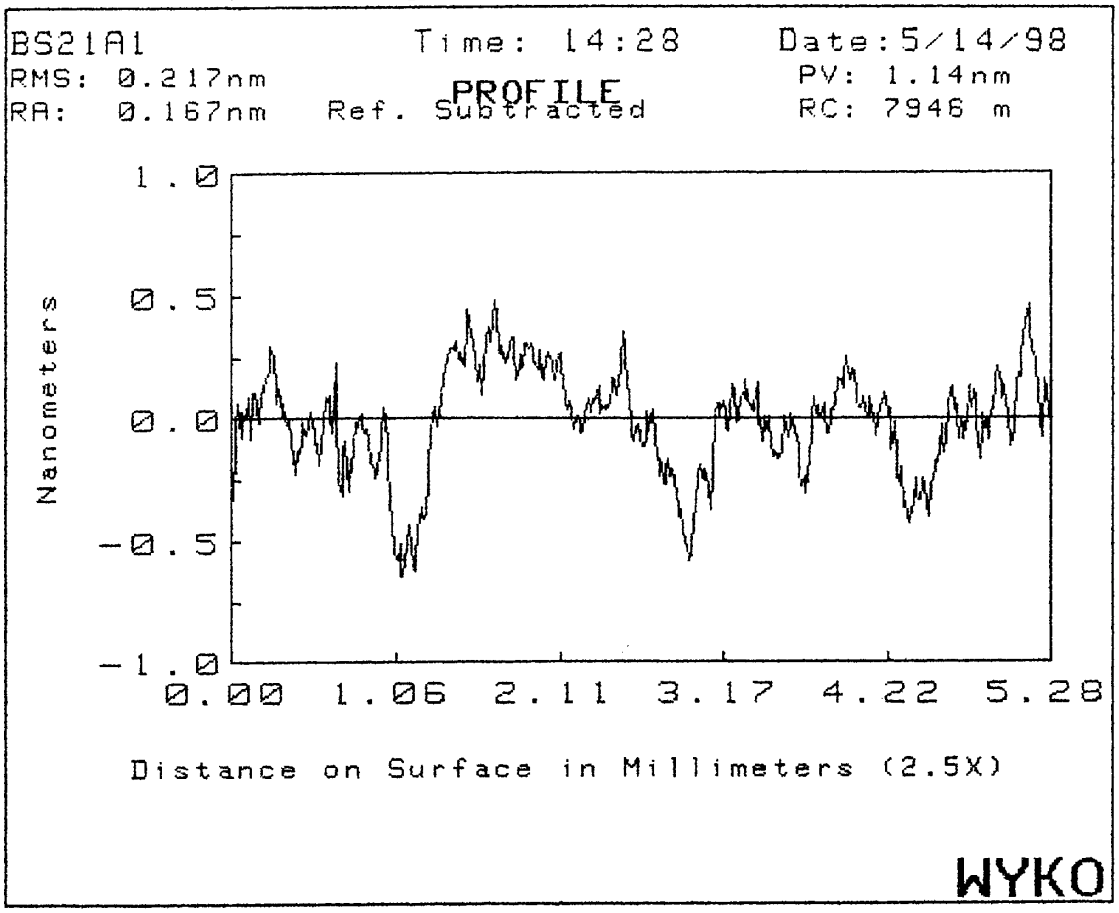
11. Certification

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: C Walsh Chris Walsh

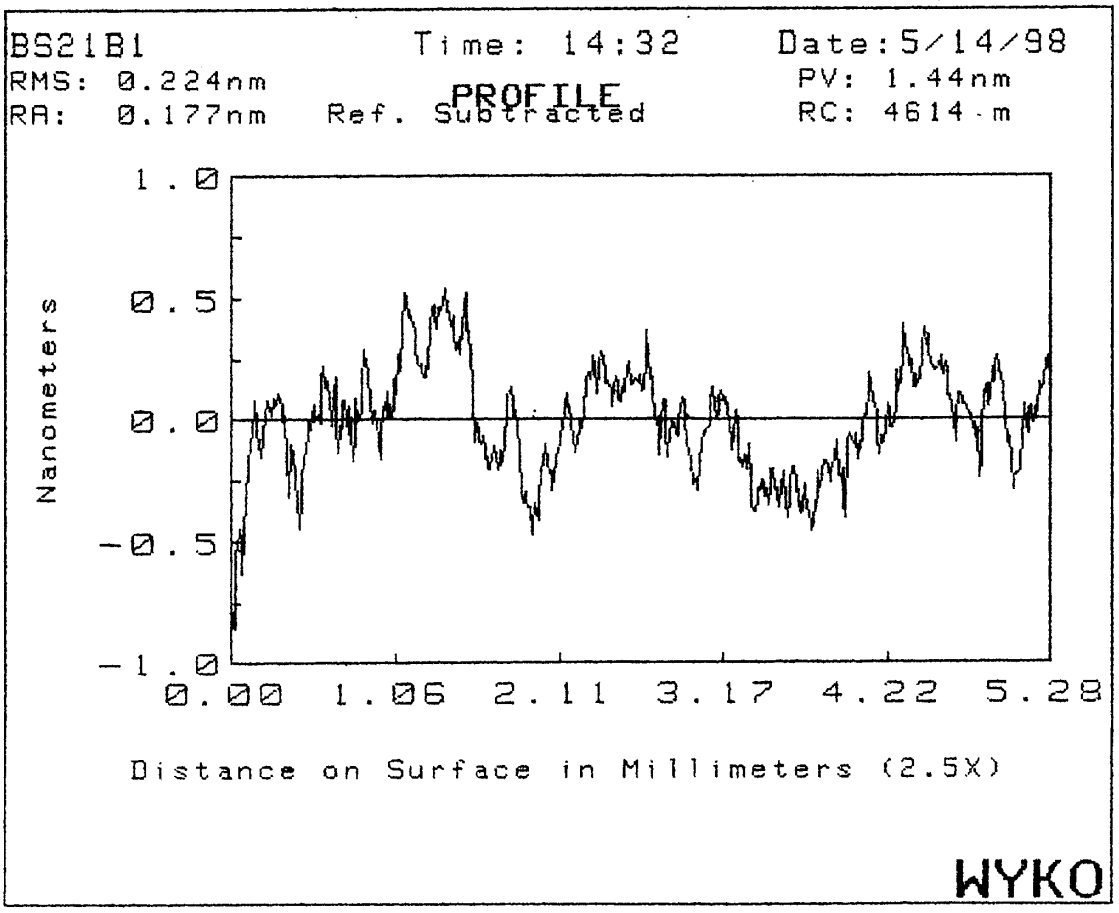
Date: 19 June 98

T2BS21A.asc

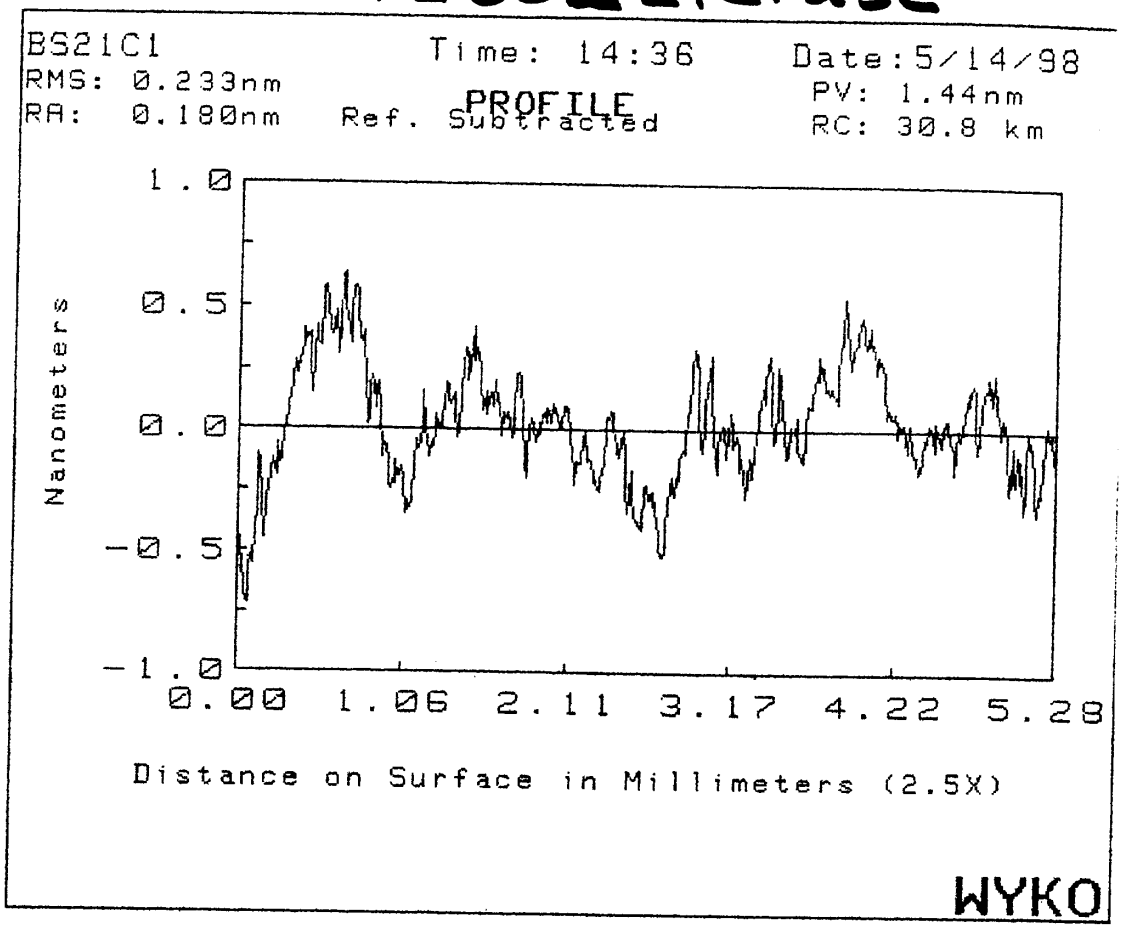


Att.3

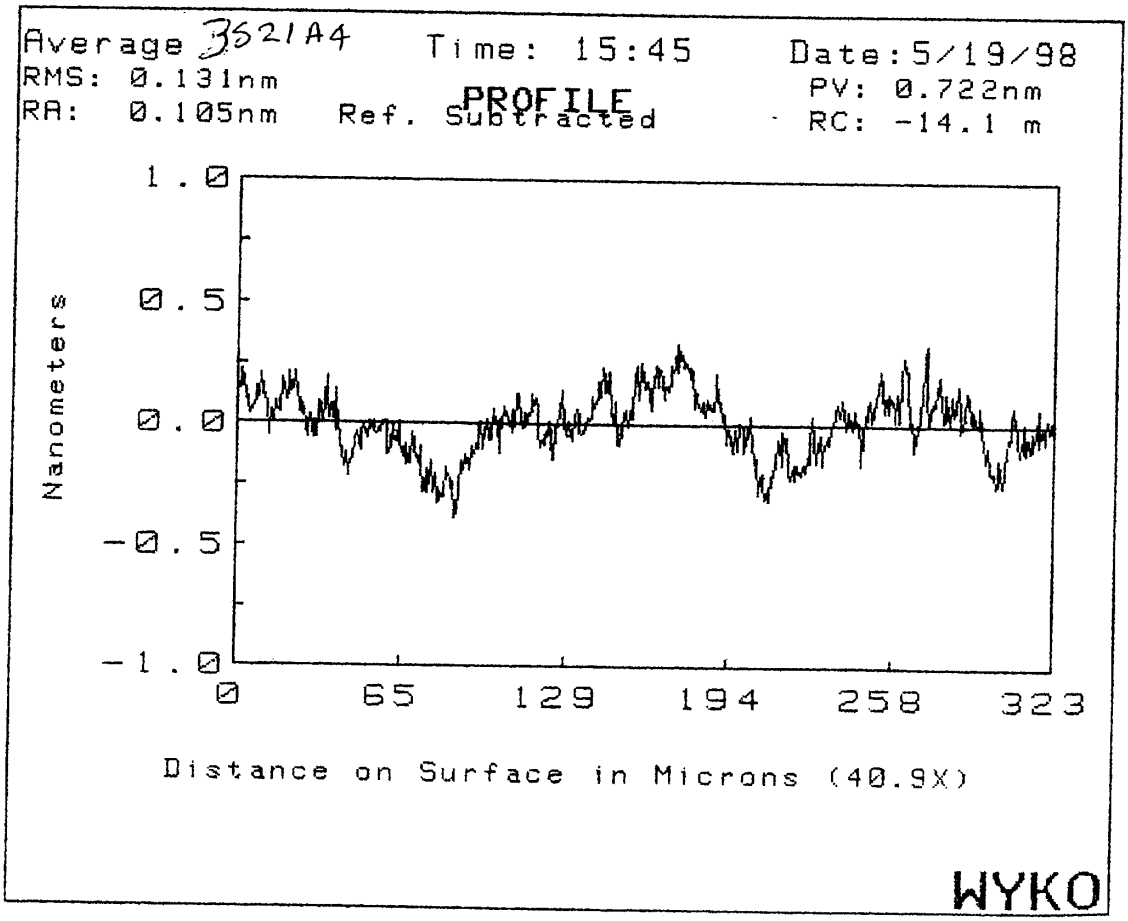
T2BS21B.asc



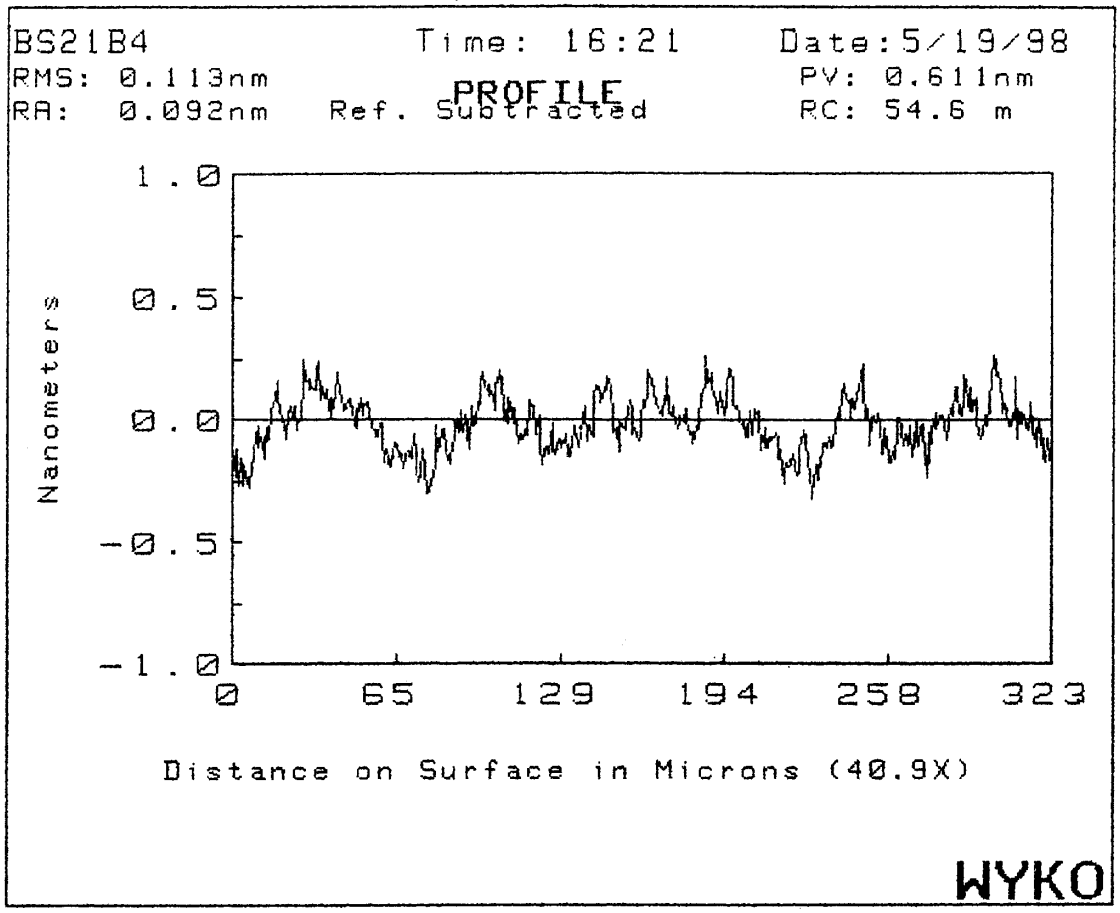
T2BS21C.asc



T4BS21A.asc



T4BS21B.asc



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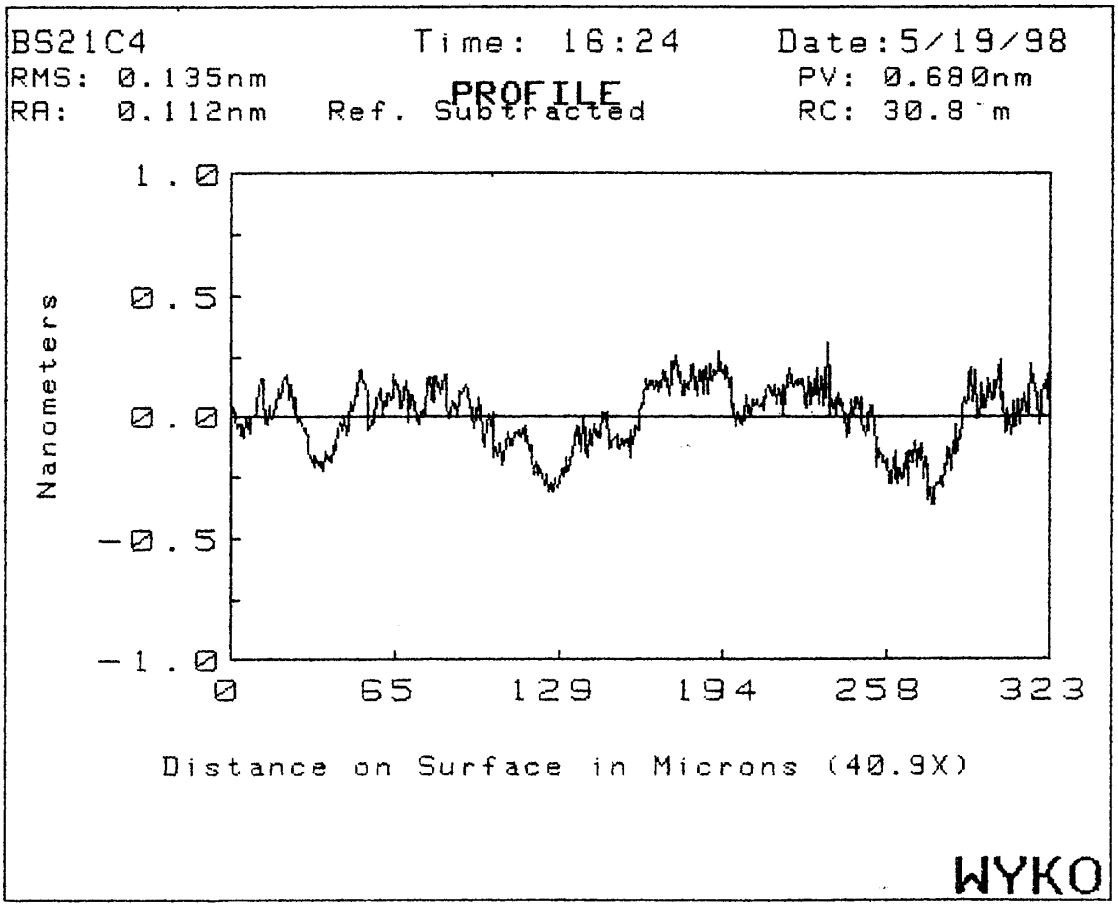

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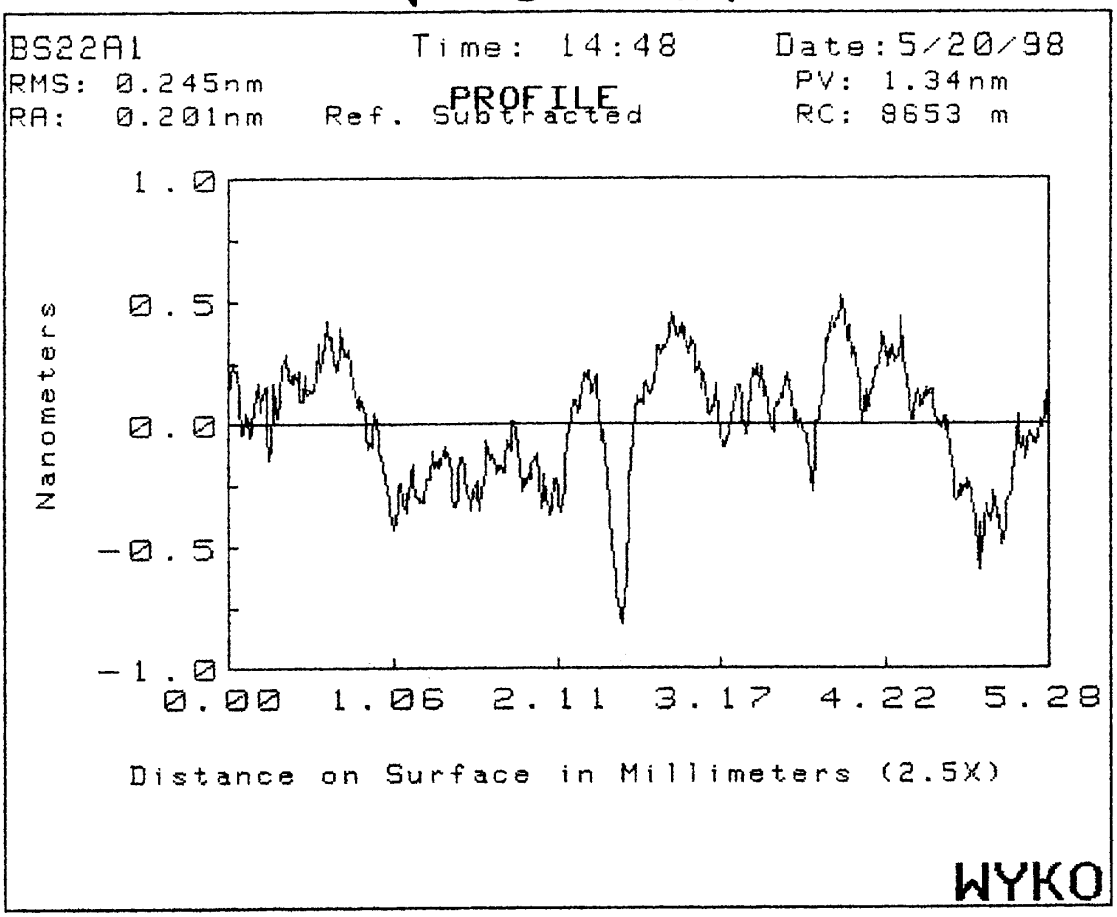
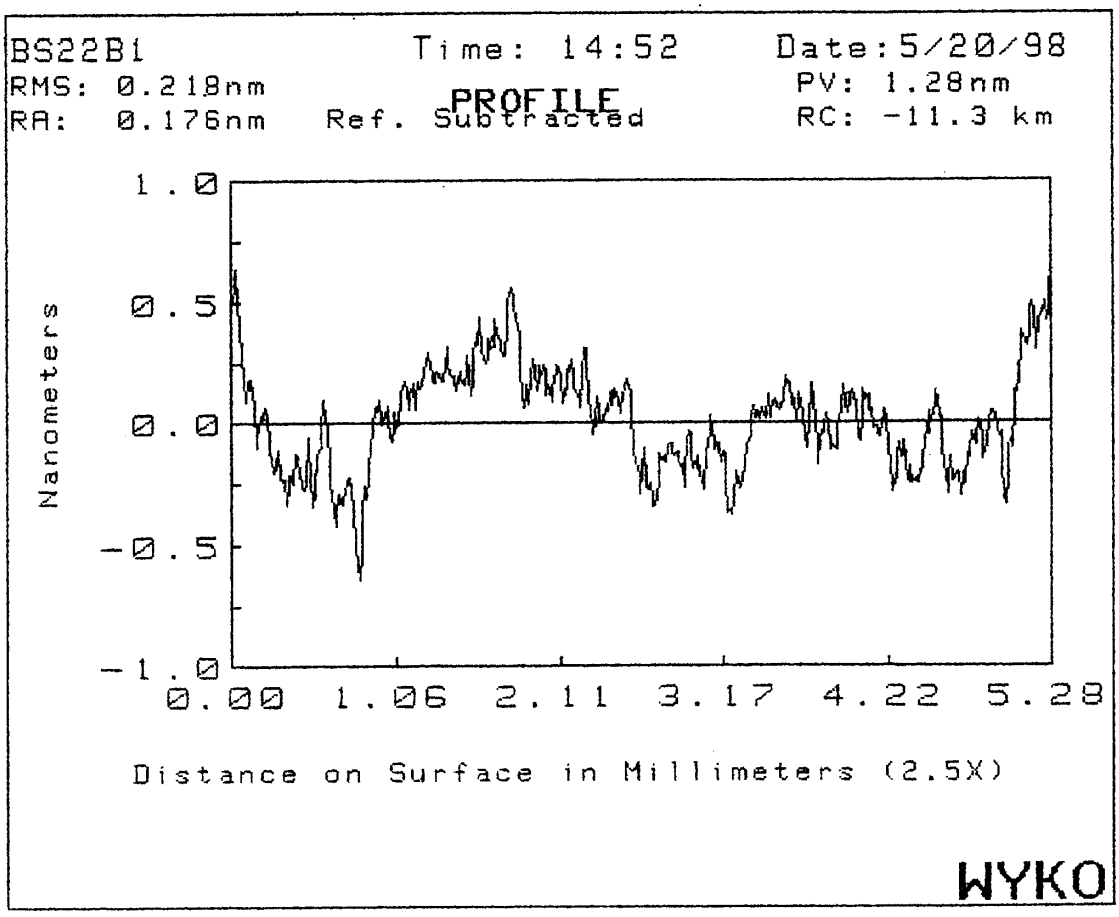
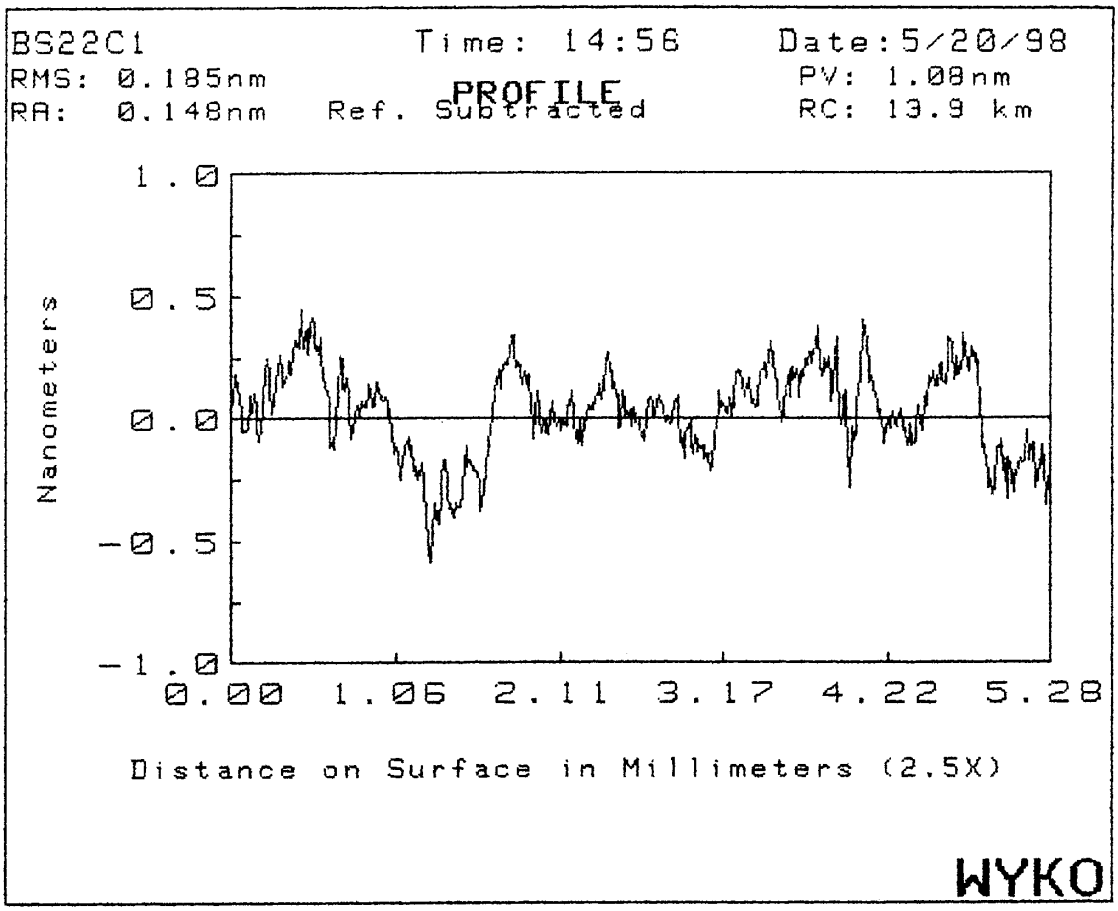


Att. 4

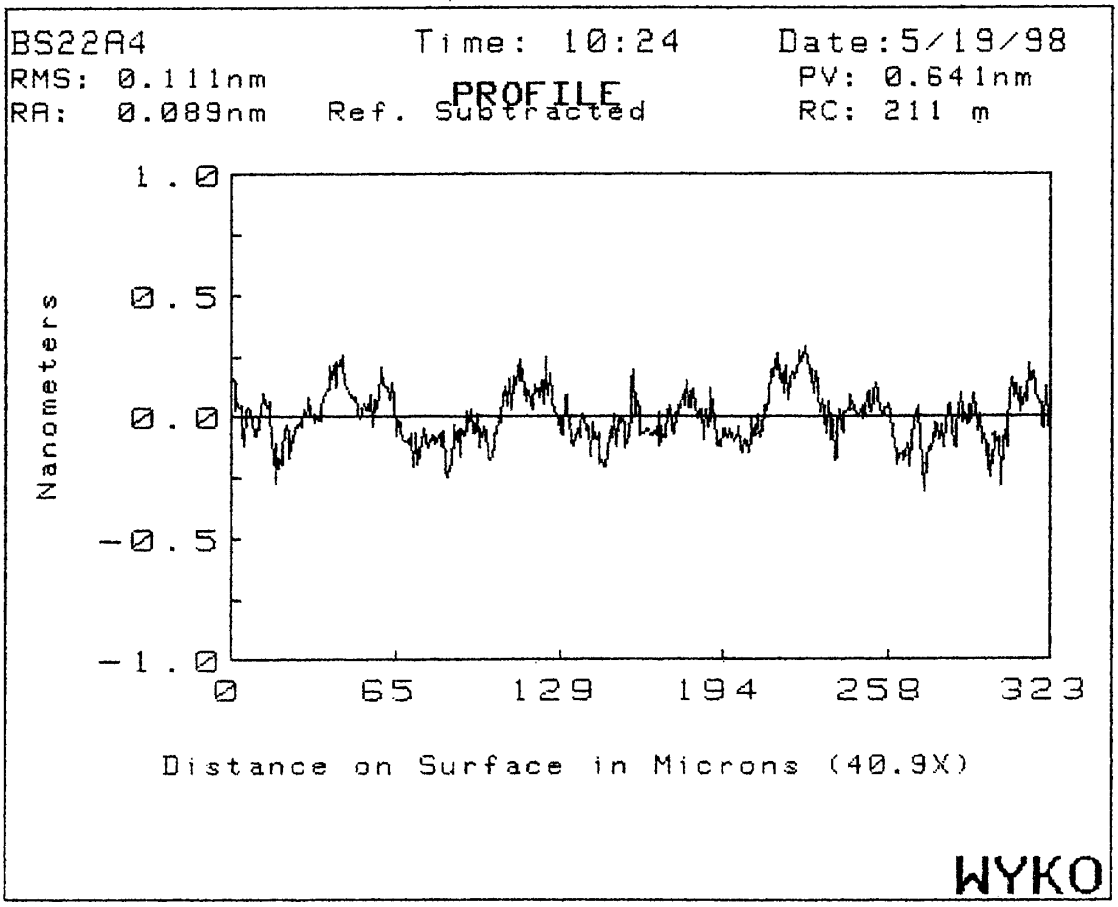
T2BS22B.asc



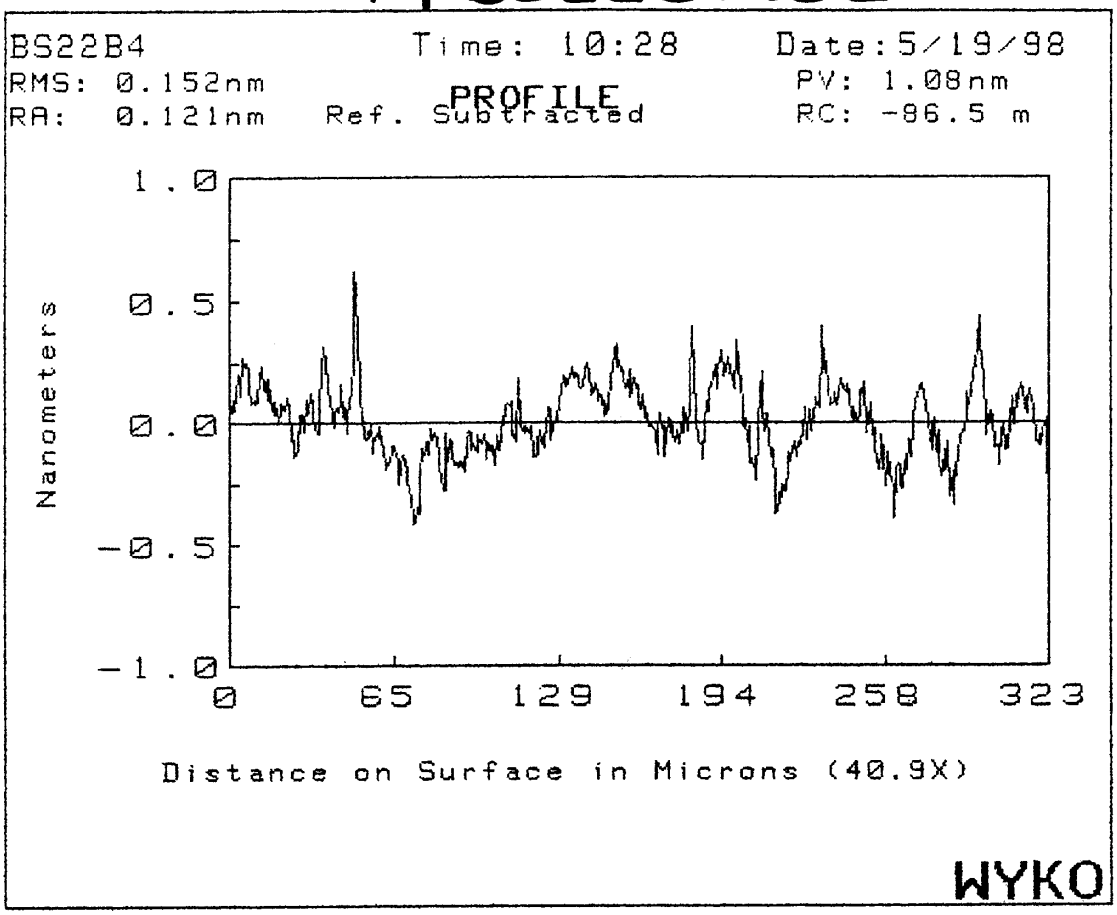
T2 BS22C.asc



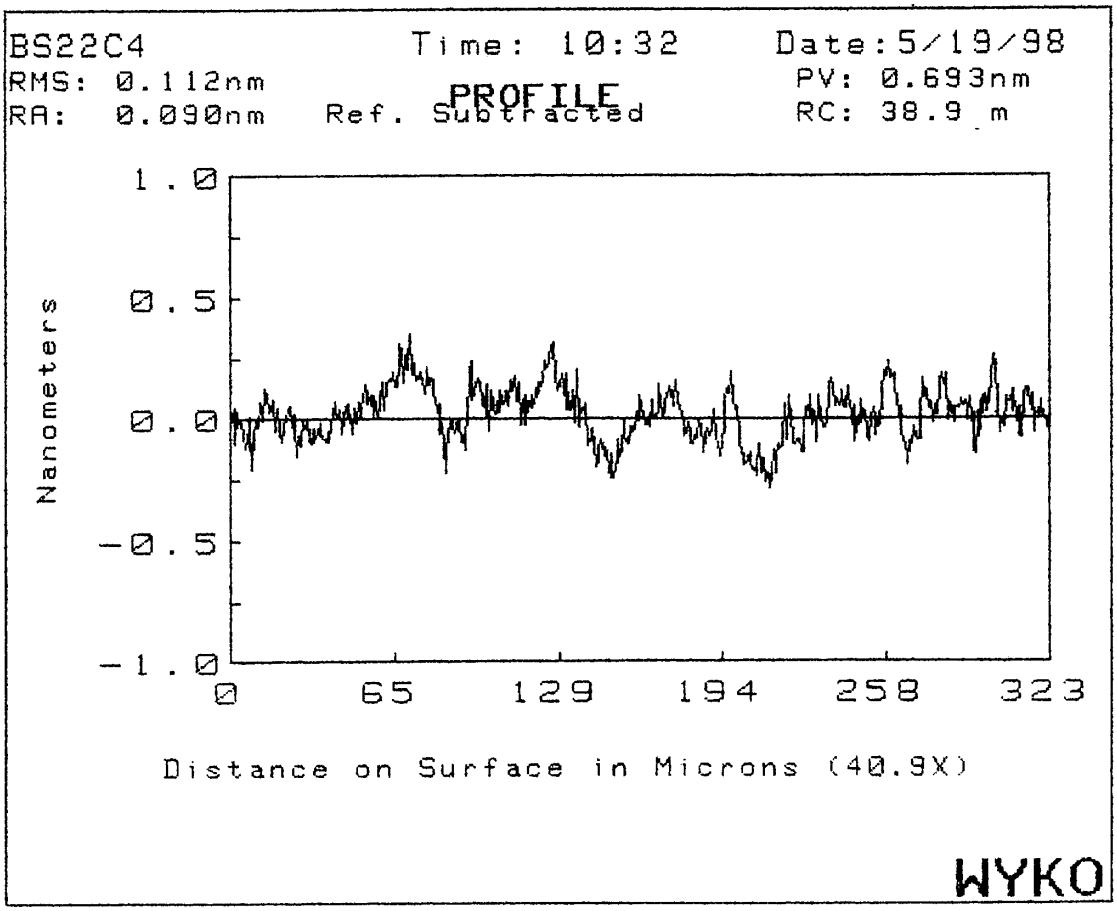
T4 BS22A.asc



T4 BS22B.asc



T4 BS22C.asc



07-02-98

#36

LINDA STOHR CHB, INC
11099 S LA CIENEGA BLVD #258
LOS ANGELES, CA 90045
(310)216-6446

DATE	OUR REF. NO.
6/25/98	7206

THE MERCHANDISE DESCRIBED BELOW WILL BE ENTERED AND/OR FORWARDED AS FOLLOWS:

CARRIER	LOCATION	ORIGIN/DESTINATION PORT
NZ	Y350 AIR NEW ZEALAND	

B/L OR AWB NO.	ARR./DEPT. DATE	FREE TIME EXP.	LOCAL DELIVERY OR TRANSFER BY (DELIVERY ORDER ISSUED TO)
08691504361	6/20/98	0/00/00	CUSTOM AIR TRUCKING

	HOUSE NO.	ENTRY-B/L NO.	CUST. REF. NO.
LINDA STOHR CHB, INC	43611	AWS-0007206-7	

FOR DELIVERY TO	ROUTE
CA INSTITUTE OF TECHNOLOGY 1201 E CALIFORNIA BLVD PASADENA, CA 91125	

NO. OF PKGS.	DESCRIPTION OF ARTICLES, SPECIAL MARKS & EXCEPTIONS	WEIGHT	DO NOT USE
2	MIRROR BLANKS FREIGHT PREPAID BY CENTRA WORLDWIDE, P.O.#6762 TAG NO. T- 486141 P/U DRIVER # DEL DRIVER # BS02	187 LB	

INLAND FREIGHT

PREPAID / COLLECT: Prepaid

Received in Good Order
By:

DATE: TIME:

DELIVERY CLERK: DELIVER TO CARRIER SHOWN ABOVE

PER: (310)216-6446

Rec'd 07-02-98

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

TO: STEVE ELIESON
CAL TECH LIGO MS 18-34
391 S. HOLLISTON AVE. CENTRAL RECEIVING
PASADENA, CA 91125

PACKING LIST NUMBER

Date OCTOBER 22, 1998	Shipped Via FEDERALEXPRESS P1 COD
Order Number PC162519/CON05	Shipment Number OPT05831

Quantity	Description
1 PC	BS SERIAL NUMBER 02 PART HAS BEEN EVALUATED. REO IS RETURNING PART TO CAL TECH TO BE REPOLISHED.


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 : 28 July 98
- Customer Name, Purchase Order No. : LIGO ; PO# PC182519/CONOS/0006
- Customer Part Number & Revision : Ligo - E980069 - 00 - D
- Part Description : Beam Splitter
- REO Job No. : OPT05831 - 021 Run No.: AR Beam splitter - 0X780 - 0X782
- Qty. Shipped/Lot No. : 1 ea - B501 1 ea - 1" FS witness
  1 ea - B502

☒ Test data (included)

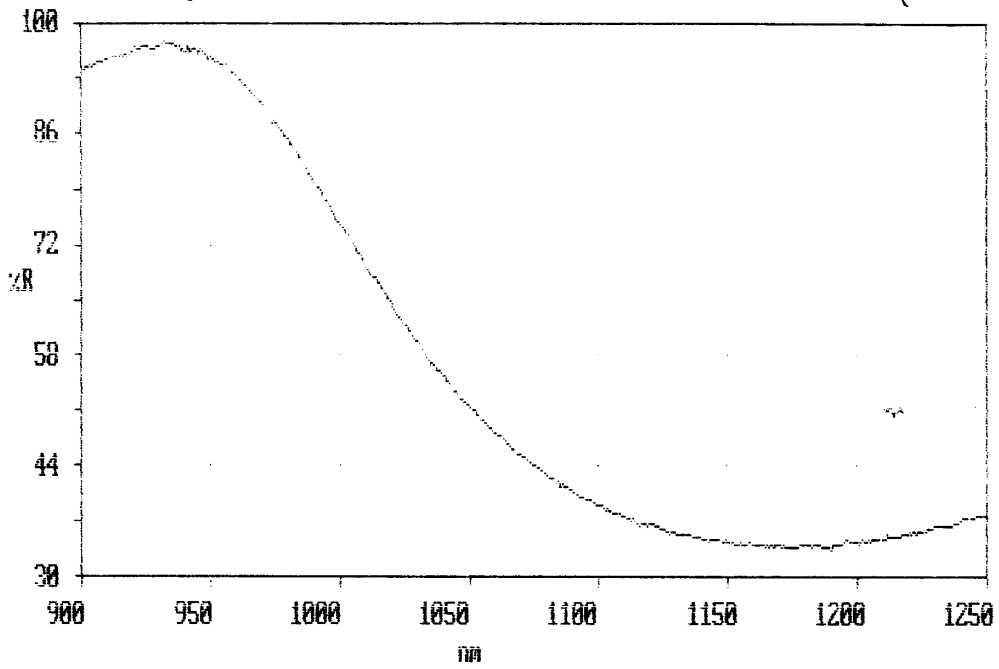
Comment:

Certified by: _____, 7/28/98
Quality Assurance

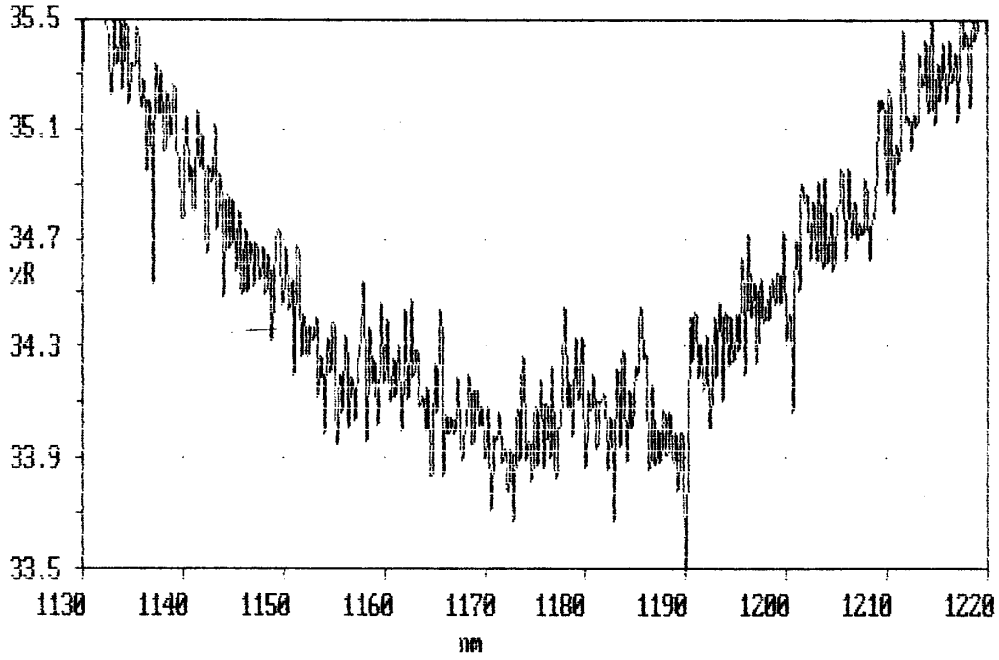
Verified by: Dale C Nedd, 28 July 98
Engr/Tech

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.

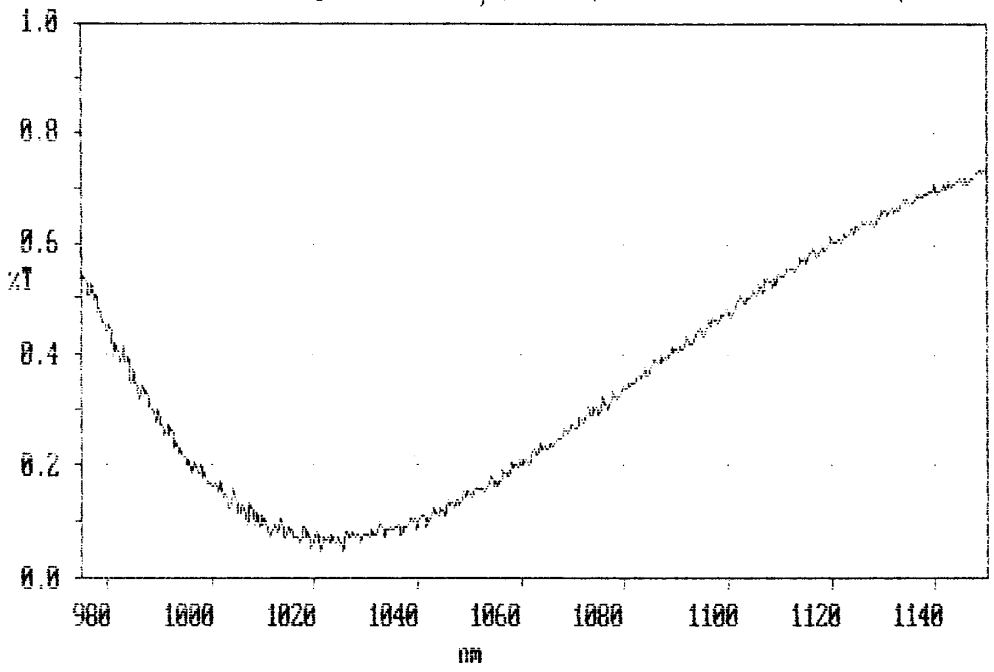
X: user001; 1250.0 - 900.0 nm; pts 1751; int 0.20; ord 33.440 - 97.860 %R
Inf: 0X780, Beamsplitter for BS01 and 02. Normal incidence scan, baked (S2 is AR coated)



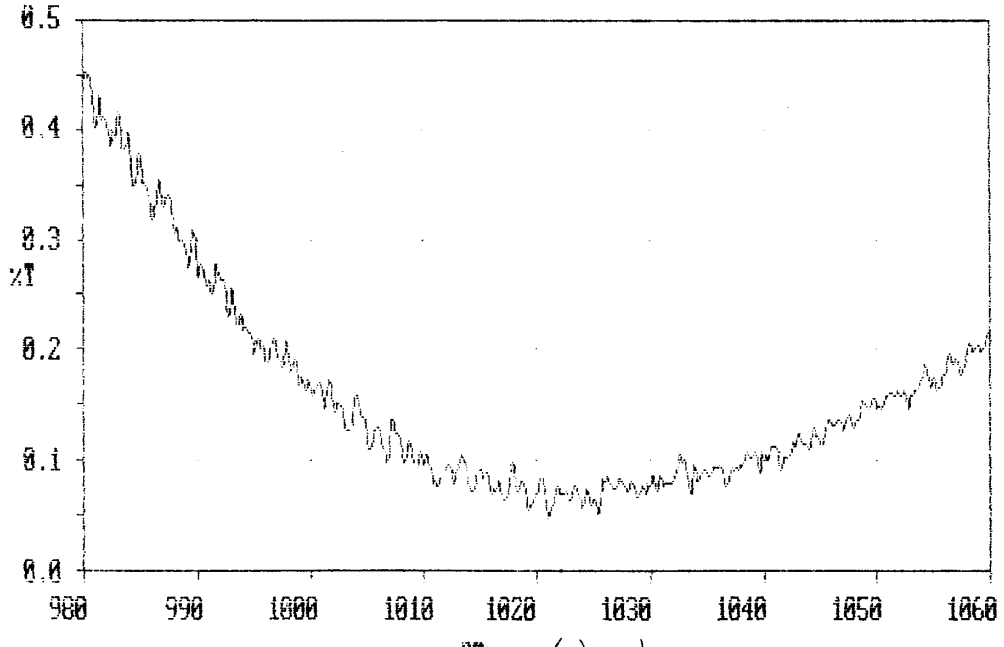
X: user001; 1250.0 - 900.0 nm; pts 1751; int 0.20; ord 33.440 - 97.860 %R
Inf: 0X780, Beamsplitter for BS01 and 02. Normal incidence scan, baked



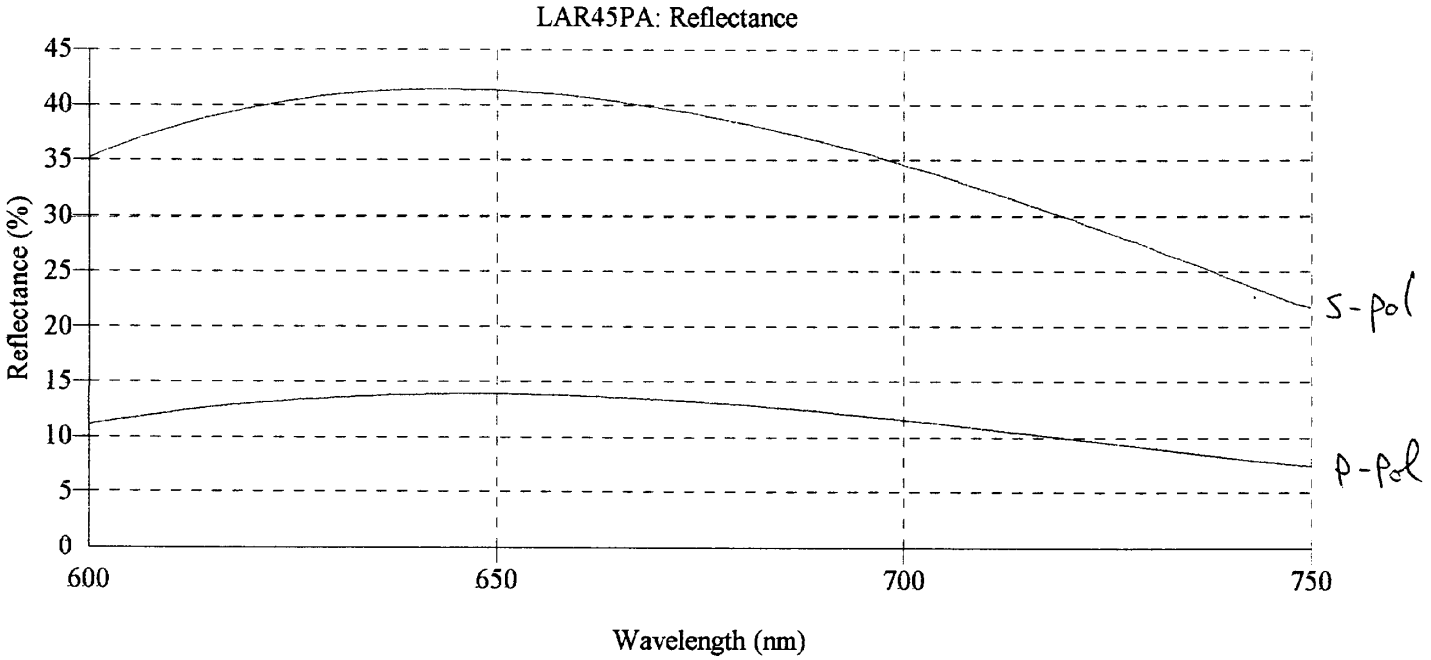
X: user001; 1150.0 - 950.0 nm; pts 1001; int 0.20; ord 0.0479 - 1.3847 %T
Inf: ox782 AR@ 1170nm @45deg after bake , Normal Incidence Scan



X: user001; 1150.0 - 950.0 nm; pts 1001; int 0.20; ord 0.0479 - 1.3847 %T
Inf: ox782 AR@ 1170nm @45deg after bake



$(\lambda_{min} @ 0^\circ) = 1023\,nm$
A.R.



Predicted performance of AR @ 45°