

**BS03-B**

**LIGO-T990136-00-D**

**BLANK**

A. DCN: LIGO-T970202-00-D LIGO DETECTOR OPTICS  
 B. LIGO S/N: BS03 Incoming Inspection Check-off Sheet  
 Core Optics Blank Material

Page 1 of 2

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.: M.F.F 8913  
 I. Date Received at Caltech: 12-01-97

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

K  Attach a copy of the glass manufacturer's <sup>inspection report</sup> ~~Certification~~ 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

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 Component Specification Verification Sheet Mirror Blanks, Beam Splitter

		Serial Number: <i>BS03</i>	Specification	Reported Value	✓
		<b>Mirror Blanks, Beam Splitter</b>  <b>Requirements</b>		Physical Dimensions	LIGO-D960793 - B
Diameter	256mm +1.0mm, -0mm			256.7 mm	✓
Thickness	<del>52.4</del> mm +1.0mm, -0mm			52.84 mm	*✓
Chamfer	2.0mm Max 2pl				
Clear Aperture	Central 235mm				
Material	Fused Silica <i>Soprasil #7980 3115</i>			Certification	✓
Registration Mark	"Top" of Optic, 80mm Arrow Points to Side 1			Certification	No
Witness Sample	25mm dia. x 25mm cylindrical			<i>shipped direct</i>	✓
Witness Sample Map				Map Attached	✓
Defect Depth	< 0.5mm			Hand Sketch w/location & dim.	No
Homogeneity Within the Central 150mm	$\leq 5.0 \times 10^{-7}$ p - v $\lambda = 632.8\text{nm}$			Interferogram Homogeneity Map	✓
Homogeneity Within the Central 225mm	$\leq 2.5 \times 10^{-6}$ p - v $\lambda = 632.8\text{nm}$			Interferogram Homogeneity Map	✓
Homogeneity Data	ASCII Format			PC Compatible 3 1/2 in. Disk	No
Birefringence Within the Central 150mm	$\leq 1$ nm/cm			Certification, Birefringence Map	✓
Birefringence Within the Central 225mm	$\leq 5$ nm/cm			Certification, Birefringence Map	✓
Bubble & Inclusion within the clear aperture. Max. Inclusion Diameter	Total $\leq 0.03\text{mm}^2$ Per $100\text{cm}^3$ of Glass. $\leq 0.1\text{mm}$			Hand Sketch w/location & dim.	No
Absorption	2ppm/cm $\lambda = 1.06\text{nm}$			Certification	No
Striae within the Clear Aperture	Grade A per MIL-G-174			Inspection Report	✓

Blnk\_BS.doc

OH: \_\_\_\_\_

Project LIGO

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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 8913  
Marking : 960095-IM 15-B503 BN 5059

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Diameter : 256,7mm  
CA Diameter :  $\emptyset 200 \text{ mm} = 0,47 \times E^{-6}$   
Thickness : 52,84 mm  
Edge : 0,3 - 0,5 mm  
Parallelism : 0,08 mm  
Roughness : ground  
 $R_a$  : 1,08  $\mu\text{m}$   
 $R_t$  : 8,86  $\mu\text{m}$   
Bubble class : 0 ; none bubbles  
Birefringence : CA  $\emptyset 200 \text{ mm} \leq 5 \text{ nm/cm}$ ;  
Homogeneity : see Interferogram  
Striae Grade : A  
Granularity : none  
Remark : Test Sample ( $\emptyset 25 \times 25 \text{ mm}$ ) with the same marking

**POL - Qualitätsprüfung Optik**

Date : 06.10.1997

Inspector : Wink

**Heraeus**  
QUARZGLAS

POL-QW

Order Nr.: 94908401 Pos.: 2

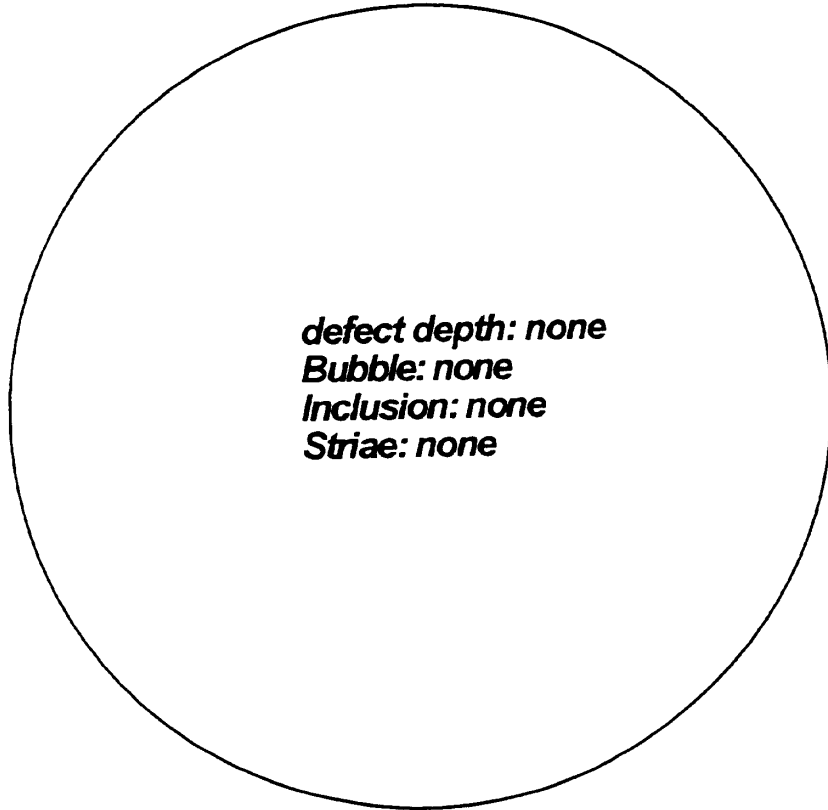
Ø 256,7 mm x 52,84 mm

Quality: Suprasil 311

Plate No.: 960095-1M 16/ 5059

Date: 6.10.97

Inspector: 



*defect depth: none*  
*Bubble: none*  
*Inclusion: none*  
*Striae: none*

Diameter	0,03mm	0,05mm	0,08mm	0,12mm	0,2mm	0,31mm	Sum
piece							
mm <sup>2</sup>							

TBCS=

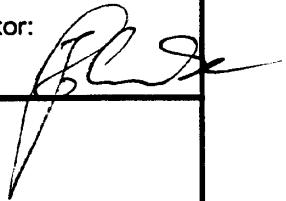
mm<sup>2</sup>  
/100cm<sup>3</sup>

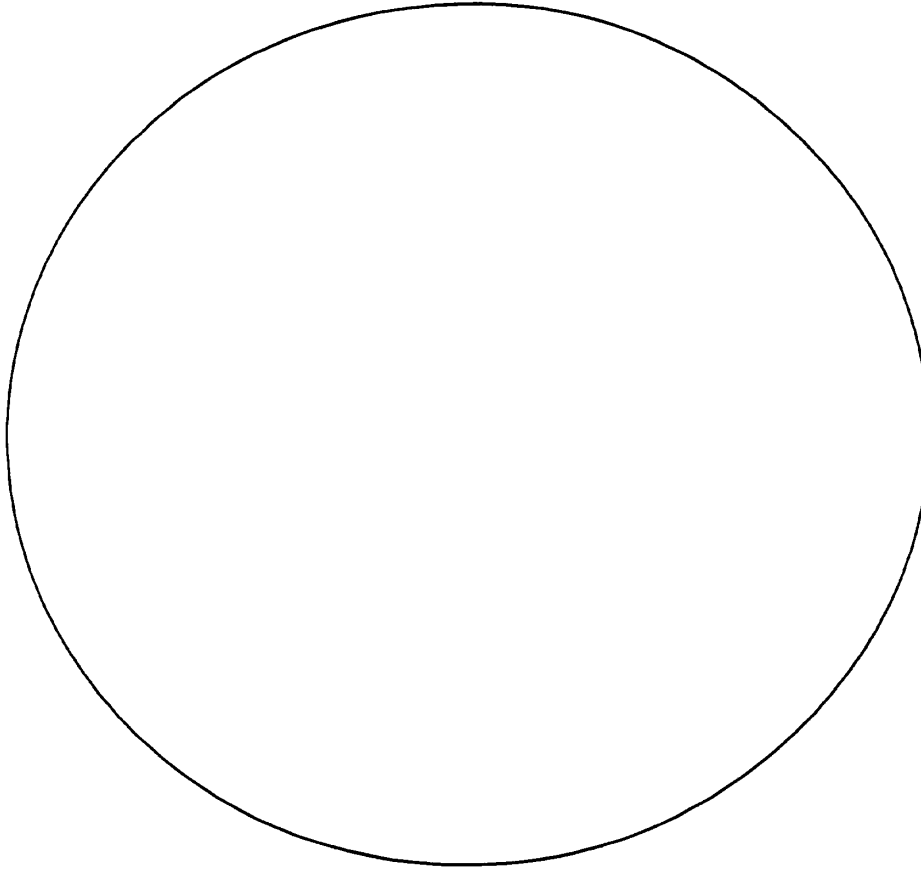
**Heraeus**  
QUARZGLAS

POL - QW

Order No.: 94908401 Pos.: 2  
Ø 256,7 mm x 52,84 mm  
Plate No.: 960095-1M 15/5059  
Residual strain- Report

Date: 6.10.97

Inspector: 



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

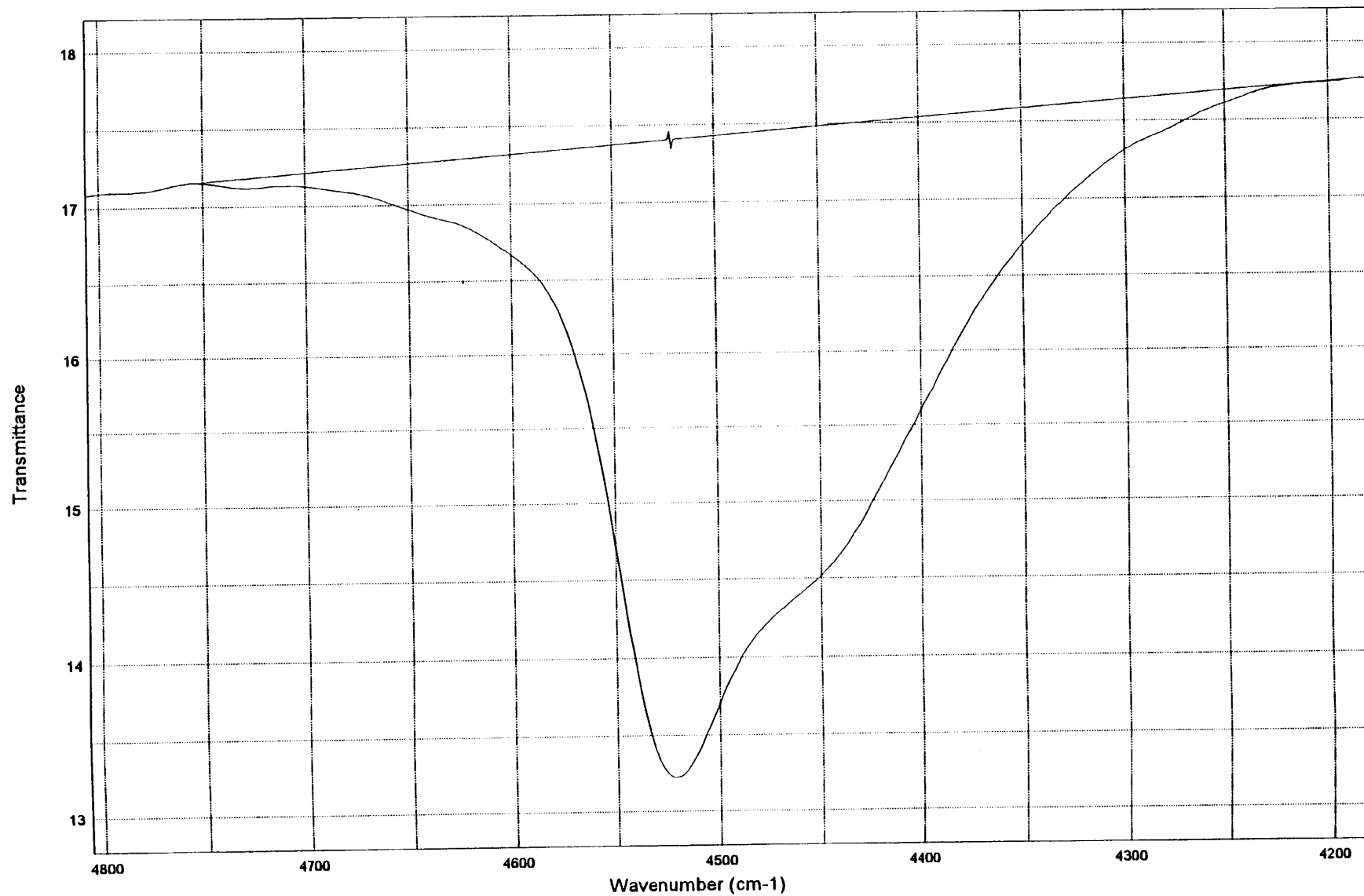


I0=17.4045 , I1=13.2243 at x=4521

OH-content: 201.9 ppm

**Heraeus**  
QUARZGLAS

MEASURE NO. : 5059  
DATE : 05.09.1997 TIME : 12:35  
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: 5059----OH-content: 201.9 ppm at x=4521



**Heraeus**  
QUARZGLAS

**POL-QW**

Data taken at 632.8 nm

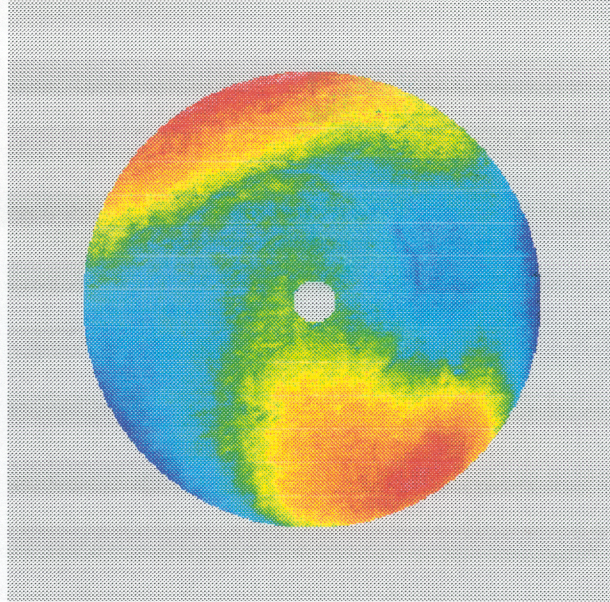
Date: 04.09.97 Operator: Rt  
ID: 505900 No.:

HQS-Order-No.: 98492874

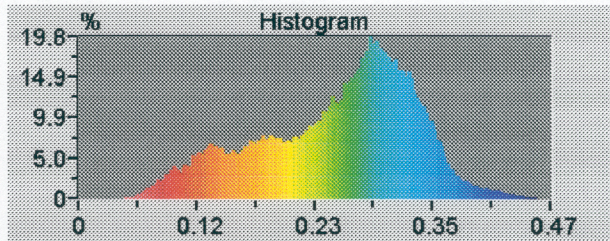
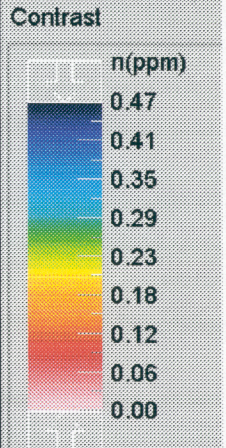
Customer: HAI  
Product: LIGO  
Pos.-No.: 2  
Order-No.:  
Comment: 960094-im-xx

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



Phase Data  
Unit n(ppm)  
PV: 0.47  
RMS: 0.076  
Scale: 0.5



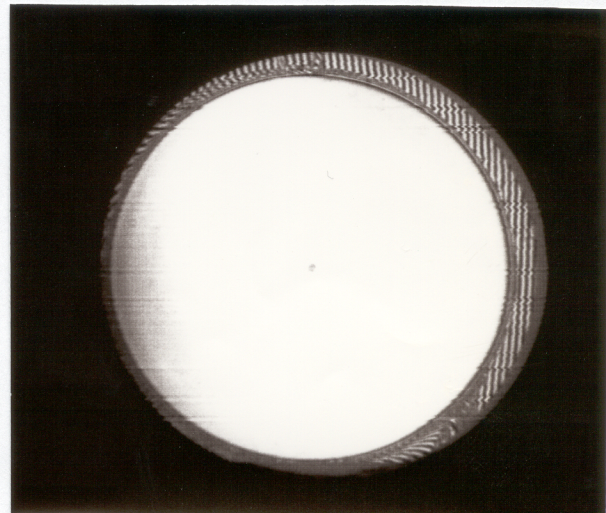
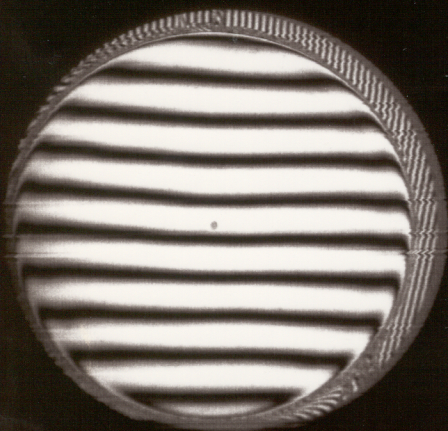
Sub. Terms	Magn.	Angle
XTilt	0.1243	-76.3872
Focus	-0.0268	
Astigm.	0.1609	-68.9243
Coma	0.0701	84.3668
SA3	0.0031	

Reset  
UpperL 0.468  
LowerL 0.000

File: 505900.tif, 04.09.97, 17:39

XPS-12"

BSØ3



Heraeus Amersil Inc  
 3473 Satellite Blvd.  
 Duluth, GA 30096

# Heraeus AMERSIL

Sales Order #: 5001652  
 Delivery #: 30039279

## Delivery Note/ Packing List


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  <i>Received complete            12-02-97  </i>	EA	11/24/1997	<p>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.</p> <p>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.</p> <p>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.</p> <p>Return no goods unless authorized. If material is not satisfactory, notify us and hold material subject to our order.</p>	6.000

Jm

**SUBSTRATE**

A. DCN: LIGO-T970203-01-D

## LIGO DETECTOR OPTICS

Page 1 of 3B. LIGO S/N: B503-BIncoming 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.: PC167159D. Substrate Polisher: E960100-B-DE. Core optic Material: BS / FM / 2ITM / 4ITM / ETM / RMF. 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 compatible 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.
- |                                     |                                  |              |                |                  |
|-------------------------------------|----------------------------------|--------------|----------------|------------------|
| <input checked="" type="checkbox"/> | Inspection of material diameter. | Diameter     | <u>9.88</u> in | <u>250.98</u> mm |
| <input checked="" type="checkbox"/> | Inspection of material thickness | Thickness    | <u>1.57</u> in | <u>39.94</u> mm  |
| <input checked="" type="checkbox"/> | Wedge Angle                      | <u>1° Ø'</u> |                |                  |
- 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: *[Signature]* Date Inspected: 10-02-98

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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.) \_\_\_\_\_

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**SKETCHES:**

See CSIRO drawing for scratch locations.

**DISPOSITIONS:** \_\_\_\_\_

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		Serial Number:	Specification	Reported Value	✓
				BS03-B	
Substrate, Beam Splitter	Surface 1	Surface Figure Over Central 200mm dia.	Flat		
		Radius of Curvature	> 200 km convex > 720 km concave	- 3600 Km (-1.4 nm)	✓
		Astigmatism	< 16nm p-v	- 5.0 nm	✓
Surface 2		Surface Figure Over Central 200mm dia.	Nominally Flat		
		Radius of Curvature of the Wavefront	> 140 km convex > 500 km concave	- 381 Km (-13.3 nm)	✓
		Astigmatism	< 23nm p-v	12.7 nm	✓
Surface Errors		Low Spatial Frequency Band Central 80mm	$\leq 4.3 \text{ cm}^{-1}$ $\sigma_{\text{rms}} < 1.6\text{nm}$	0.6 nm	✓
		Low Spatial Frequency Band Central 200mm	$\leq 4.3 \text{ cm}^{-1}$ $\sigma_{\text{rms}} < 3.2\text{nm}$	0.7 nm	✓
		High Spatial Frequency Band Central 80 & 200 mm	$\leq 4.3 - 7,500 \text{ cm}^{-1}$ $\sigma_{\text{rms}} < 0.4\text{nm}$	0.2 nm 0.2 nm	✓

Wave front 1034Km (4.7nm)

		Specification	Certification	✓
Scratches, Point Defects & Polish	Scratches	The Total Area of scratches within the central 80mm diameter shall not exceed $75 \times 10^3$ square micrometers (width x length). $< 30,000$	Hand Sketch w/dimensions	✓
		The total area of scratches outside the central 80 mm diameter shall not exceed $750 \times 10^3$ square micrometers. $< 75,000$	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. 1 scratch, 5mm in length, visible on side.	Inspection Report	✓

## LIGO Component Specification Verification Sheet Beam Splitter



## LIGO Certification Report

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

**Serial number: BS03-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)

## LIGO Certification Report

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### 2. Electronic data

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

LADI data:	BS3B1.zip	(Side 1)	BS3B2.zip (Side 2) BS3B2A.zip (wave front)
TOPO data: (2.5X)	T2BS31A.asc	(Side 1)	T2BS32A.asc (Side 2)
	T2BS31B.asc		T2BS32B.asc
	T2BS31C.asc		T2BS32C.asc
(40X)	T4BS31A.asc		T4BS32A.asc
	T4BS31B.asc		T4BS32B.asc
	T4BS31B.asc		T4BS32C.asc

LIGO Certification Report      **Physical Dimensions**

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<b>1</b>	<b>Substrate Type:</b>	<b>Beamsplitter</b>
<b>2</b>	<b>Serial Number:</b>	<b>BS03-B</b>
<b>3</b>	<b>Physical quantity certified:</b>	<b>Physical Dimensions and Registration Mark</b>
<b>4</b>	<b>LIGO specification reference:</b>	<b>D960789-B-D</b>
<b>5</b>	<b>CSIRO measurement/inspection procedure reference:</b>	<b>HABA-LIGO-M-PD</b>
<b>6</b>	<b>Variations to the measurement/inspection procedure:</b> (indicate Yes/No and attach separate sheet if Yes)	<b>No</b>
<b>7</b>	<b>CSIRO Log Book Reference</b>	<b>LN00028</b>
<b>8</b>	<b>Team member responsible for measurement/inspection:</b>	<b>C Sona</b>
<b>9</b>	<b>Measurement/inspection results reviewed by:</b>	<b>C Walsh</b>

**10. Results**

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

Physical Quantity	Result
Diameter	250.98 mm
Cylindricity	0.01 mm
Thickness      (maximum - for FM, RM, ETM) (minimum - for BS)	39.94 mm
Bevel as per drawing (height, angle):	(S1) Height: 2.25 mm Angle:45 <sup>0</sup> 18' (S2) Height: 2.09 mm Angle:44 <sup>0</sup> 40'
Wedge angle:	1 <sup>0</sup> 0'
Location of registration mark ( $\pm$ angle with respect to minimum part thickness):	+3'
Location of other 3 marks (with respect to registration mark at minimum thickness)	90 <sup>0</sup> , 179 <sup>0</sup> 58', 269 <sup>0</sup> 57'
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*

**LIGO Certification Report      Side and Bevel Polish**

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<b>1</b>	<b>Substrate Type:</b>	<b>Beamsplitter</b>
<b>2</b>	<b>Serial Number:</b>	<b>BS03-B</b>
<b>3</b>	<b>Physical quantity certified:</b>	<b>Side and Bevel Polish</b>
<b>4</b>	<b>LIGO specification reference:</b>	<b>E960100-B-D</b>
<b>5</b>	<b>CSIRO measurement/inspection procedure reference:</b>	<b>HABA-LIGO-M-SB-A</b>
<b>6</b>	<b>Variations to the measurement/inspection procedure:</b> (indicate Yes/No and attach separate sheet if Yes)	<b>No</b>
<b>7</b>	<b>CSIRO Log Book Reference</b>	<b>LN00062</b>
<b>8</b>	<b>Team member responsible for measurement/inspection:</b>	<b>E Pavlovic</b>
<b>9</b>	<b>Measurement/inspection results reviewed by:</b>	<b>J Seckold</b>

**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"*).

**One scratch, 5 mm in length, visible on side.**

**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	<b>Substrate Type:</b>	<b>Beamsplitter</b>
2	<b>Serial Number:</b>	<b>BS03-B</b>
3	<b>Physical quantity certified:</b>	<b>Serial Number and location</b>
4	<b>LIGO specification reference:</b>	<b>E960100-B-D</b>
5	<b>CSIRO measurement/inspection procedure reference:</b>	<b>HABA-LIGO-M-SN-A</b>
6	<b>Variations to the measurement/inspection procedure:</b> (indicate Yes/No and attach separate sheet if Yes)	<b>No.</b>
7	<b>CSIRO Log Book Reference</b>	<b>LN00062</b>
8	<b>Team member responsible for measurement/inspection:</b>	<b>E Pavlovic</b>
9	<b>Measurement/inspection results reviewed by:</b>	

### 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	<b>Substrate Type:</b>	<b>Beamsplitter</b>
2	<b>Serial Number:</b>	<b>BS03-B</b>
3	<b>Physical quantity certified:</b>	<b>Scratches and Point Defects</b>
4	<b>LIGO specification reference:</b>	<b>E960100-B-D</b>
5	<b>CSIRO measurement/inspection procedure reference:</b>	<b>HABA-LIGO-M-SP-A</b>
6	<b>Variations to the measurement/inspection procedure:</b> (indicate Yes/No and attach separate sheet if Yes)	<b>No.</b>
7	<b>CSIRO Log Book Reference</b>	<b>LN00062</b>
8	<b>Team member responsible for measurement/inspection:</b>	<b>E Pavlovic</b>
9	<b>Measurement/inspection results reviewed by:</b>	<b>C Walsh</b>

## 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)
<b>Surface 1</b>	<b>nil</b>	<b>nil</b>	<b>&lt; 30,000</b>	<b>&lt; 75,000</b>
<b>Surface 2</b>	<b>nil</b>	<b>nil</b>	<b>&lt; 30,000</b>	<b>&lt; 20,000</b>

The average scratch width is 5  $\mu\text{m}$ .

## 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



Each number in  
units of  $10^3 \mu m$ .



~~Thin~~

121

BSO 3  
SIDE 2

14

104

131

Each number in  
units of  $10^3 \mu\text{m}$ .

1	<b>Substrate Type:</b>	<b>Beamsplitter</b>
2	<b>Serial Number:</b>	<b>BS03-B</b>
3	<b>Physical quantity certified:</b>	<b>Surface Figure</b>
4	<b>LIGO specification reference:</b>	<b>E960100-B-D</b>
5	<b>CSIRO measurement/inspection procedure reference:</b>	<b>HABA-LIGO-M-SF-A</b>
6	<b>Variations to the measurement/inspection procedure:</b> (indicate Yes/No and attach separate sheet if Yes)	<b>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)</b>
7	<b>CSIRO Log Book Reference</b>	<b>LLN/0137-01 pp 29-30</b>
8	<b>Team member responsible for measurement/inspection:</b>	<b>D Farrant</b>
9	<b>Measurement/inspection results reviewed by:</b>	<b>B Oreb</b>

## 10. Results

	<b>Radius of Curvature in km (Parabolic sag in nm)</b>	<b>Astigmatism (nm)</b>	<b>Electronic data file reference</b>
<b>Surface 1</b>	<b>-3600 km (-1.4 nm)</b>	<b>-5.0</b>	<b>BS3B1.zip</b>
<b>Surface 2</b>	<b>-381 km (-13.3 nm)</b>	<b>12.7</b>	<b>BS3B2. zip</b>
<b>Wave front*</b>	<b>1034 km (4.7 nm)</b>		<b>BS3B2A.zip</b>

\* 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 nm, which lies within the tolerance band agreed with Caltech of 14 nm> Sag > -50 nm.

1	<b>Substrate Type:</b>	<b>Beamsplitter</b>
2	<b>Serial Number:</b>	<b>BS03-B</b>
3	<b>Physical quantity certified:</b>	<b>Surface Figure</b>
4	<b>LIGO specification reference:</b>	<b>E960100-B-D</b>
5	<b>CSIRO measurement/inspection procedure reference:</b>	<b>HABA-LIGO-M-SF-A</b>
6	<b>Variations to the measurement/inspection procedure:</b> (indicate Yes/No and attach separate sheet if Yes)	<b>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)</b>
7	<b>CSIRO Log Book Reference</b>	<b>LLN/0137-01 pp 29-30</b>
8	<b>Team member responsible for measurement/inspection:</b>	<b>D Farrant</b>
9	<b>Measurement/inspection results reviewed by:</b>	<b>B Oreb</b>

## 10. Results

	<b>Radius of Curvature in km (Parabolic sag in nm)</b>	<b>Astigmatism (nm)</b>	<b>Electronic data file reference</b>
<b>Surface 1</b>	<b>-3600 km (-1.4 nm)</b>	<b>-5.0</b>	<b>BS3B1.zip</b>
<b>Surface 2</b>	<b>-381 km (-13.3 nm)</b>	<b>12.7</b>	<b>BS3B2. zip</b>
<b>Wave front*</b>	<b>1034 km (4.7 nm)</b>		<b>BS3B2A.zip</b>

\* 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 4.7 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

Title: BS\_31

Date: 05/31/98

Diameter: 200 mm

Astig: -5.0 nm

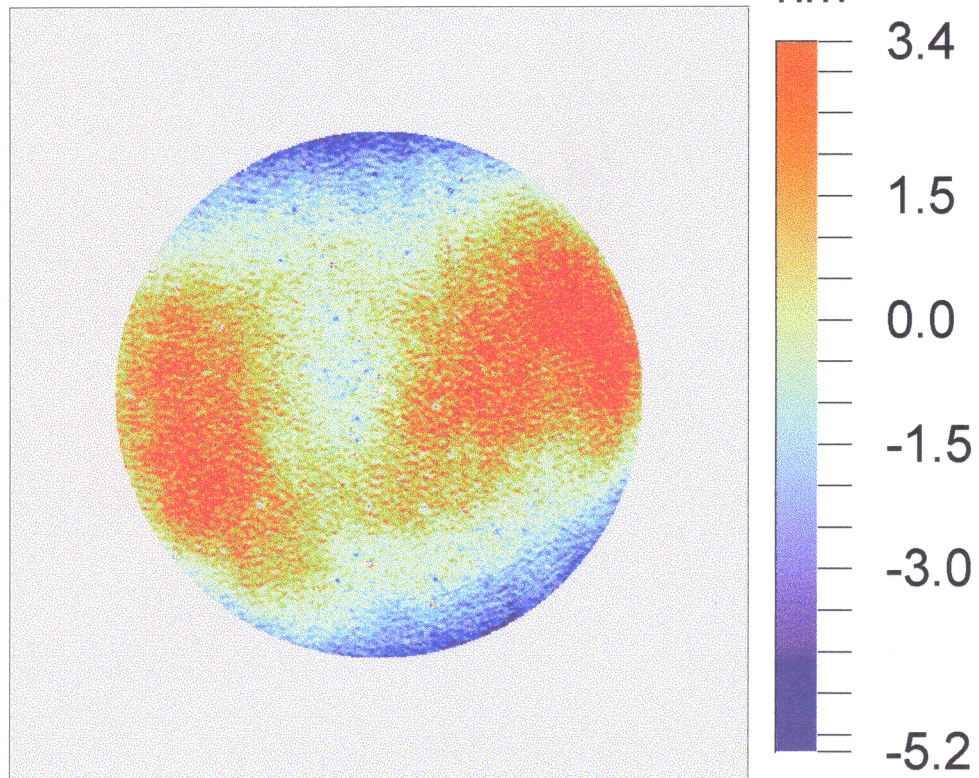
Power: -1.4 nm



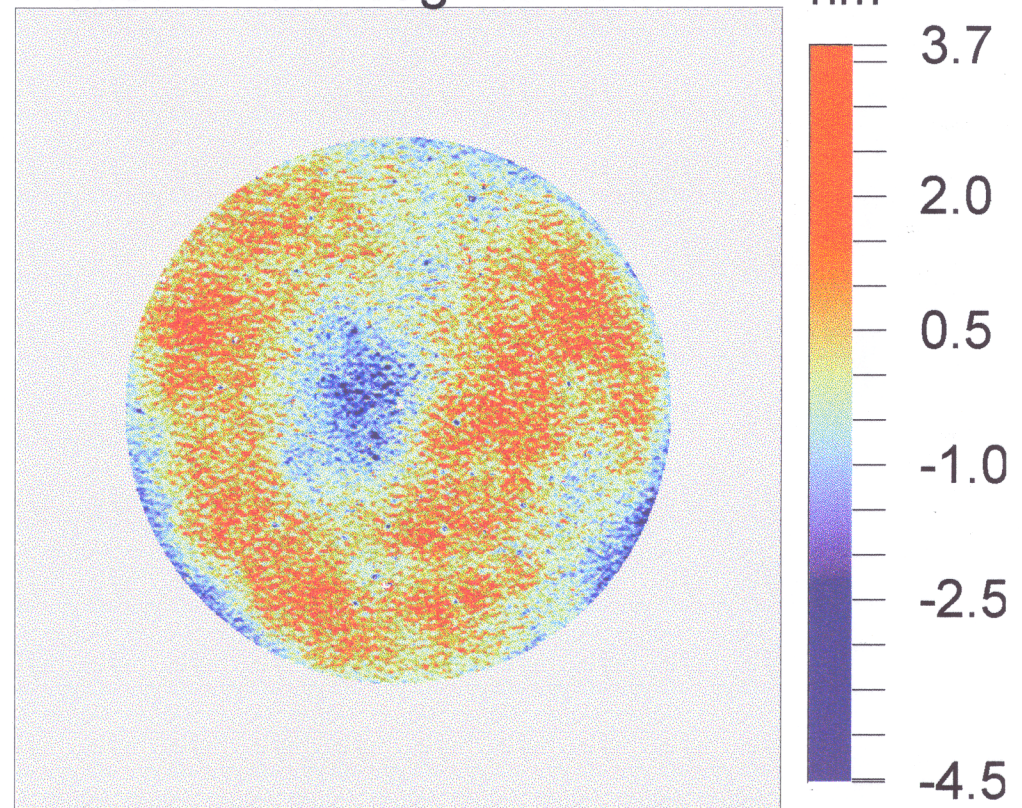
PV: 8.2 nm

RMS: 0.7 nm

Tilt Removed



Tilt/Power/Astig Removed



# LADI CERTIFICATION DATA

Title: BS\_32

Date: 05/31/98

Diameter: 200 mm

Astig: -7.5 nm

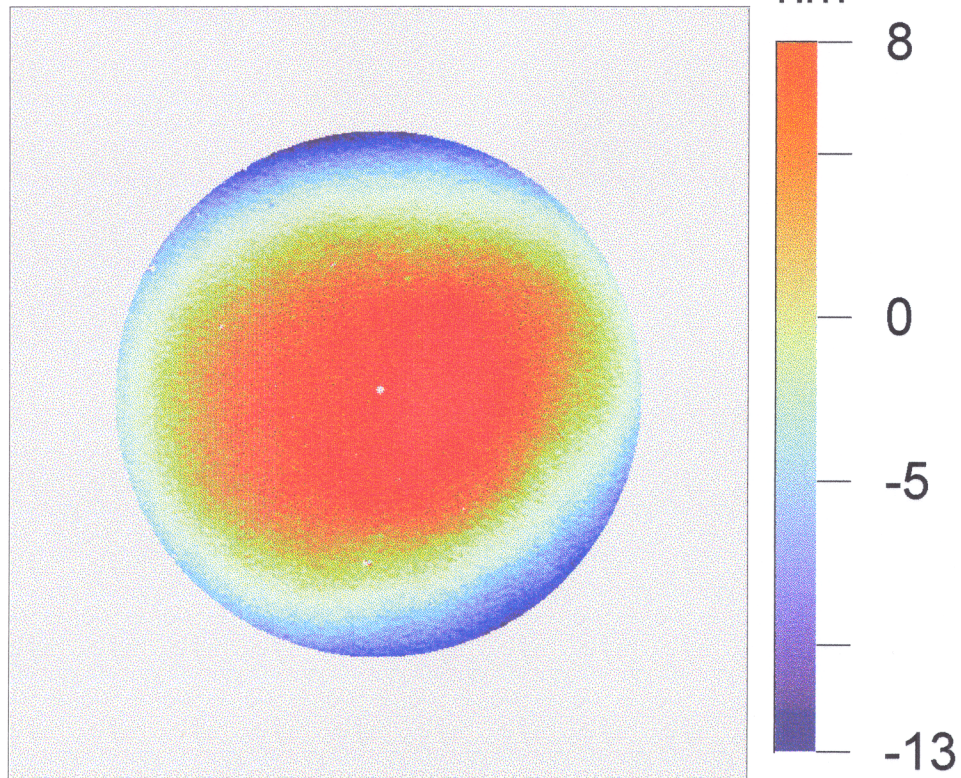
Power: -13.3 nm



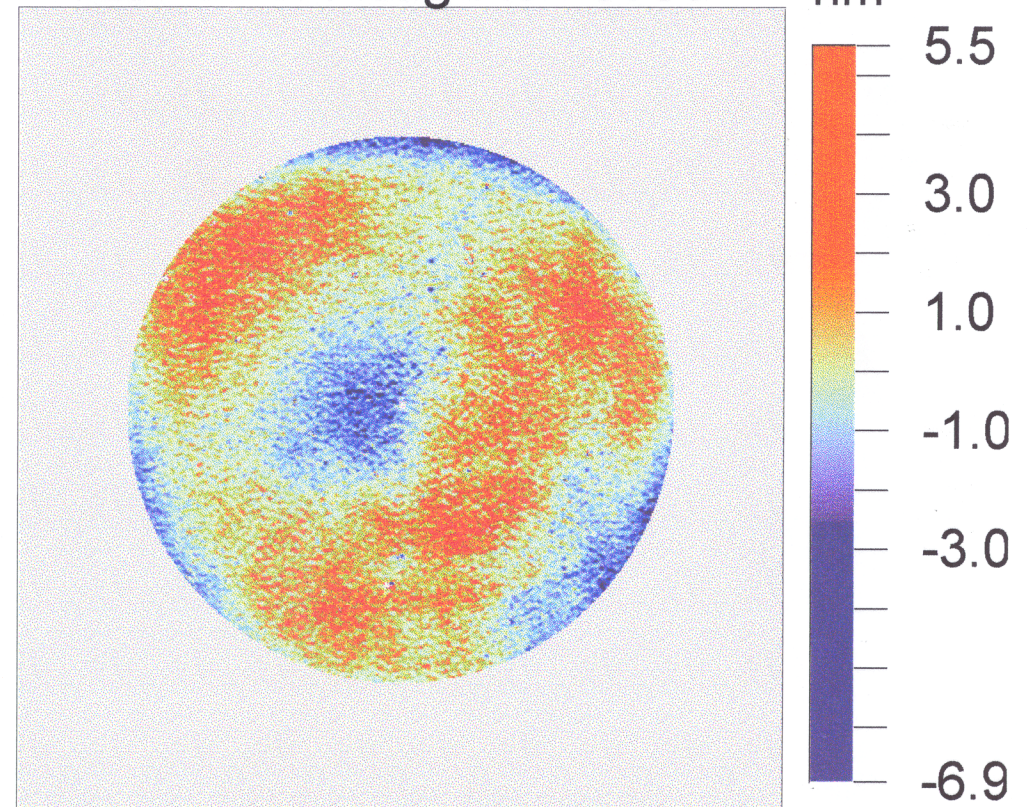
PV: 12.4 nm

RMS: 0.9 nm

Tilt Removed



Tilt/Power/Astig Removed



# LADI CERTIFICATION DATA

Title: BS\_3T

Date: 05/31/98

Diameter: 200 mm

Astig: 12.7 nm

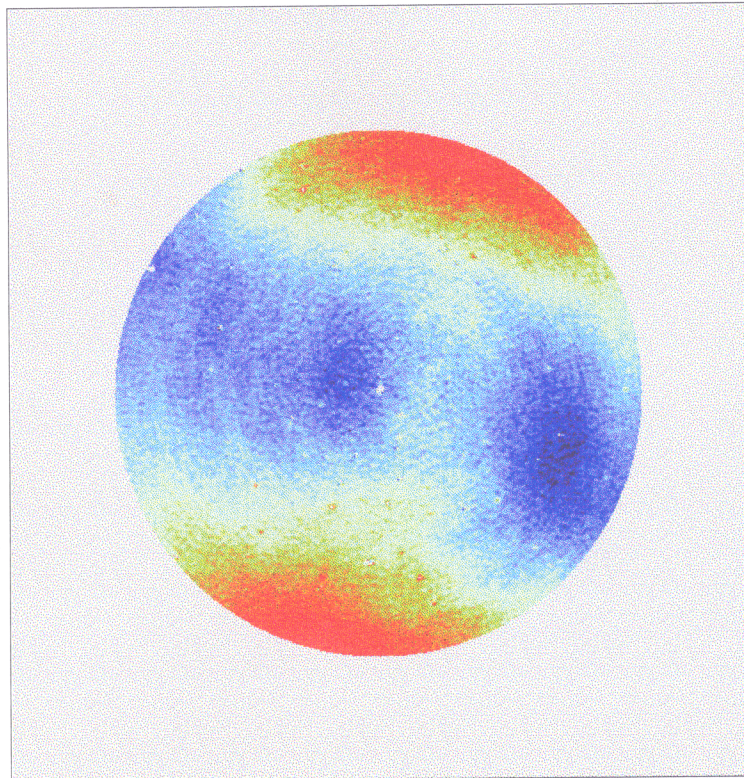
Power: 4.7 nm



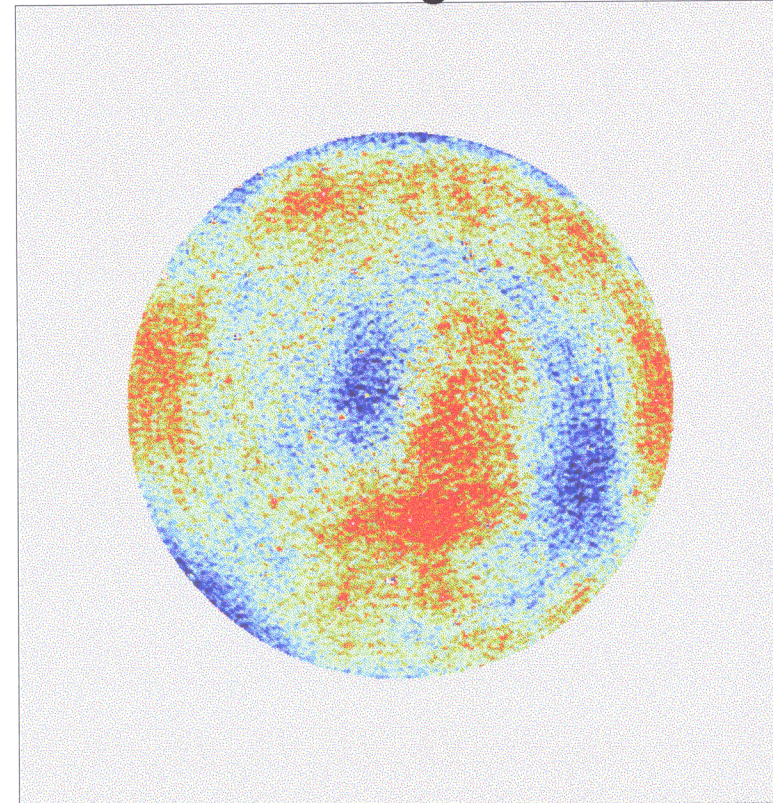
PV: 11.6 nm

RMS: 1.0 nm

Tilt Removed



Tilt/Power/Astig Removed



**LIGO Certification Report      Surface Errors - Low**

<b>1</b>	<b>Substrate Type:</b>	<b>Beamsplitter</b>
<b>2</b>	<b>Serial Number:</b>	<b>BS03-B</b>
<b>3</b>	<b>Physical quantity certified:</b>	<b>Surface Errors - Low Spatial Frequency</b>
<b>4</b>	<b>LIGO specification reference:</b>	<b>E960100-B-D</b>
<b>5</b>	<b>CSIRO measurement/inspection procedure reference:</b>	<b>HABA-LIGO-M-SL-A</b>
<b>6</b>	<b>Variations to the measurement/inspection procedure:</b> (indicate Yes/No and attach separate sheet if Yes)	<b>No</b>
<b>7</b>	<b>CSIRO Log Book Reference</b>	<b>LLN/0137-01 pp 29-30</b>
<b>8</b>	<b>Team member responsible for measurement/inspection:</b>	<b>D Farrant</b>
<b>9</b>	<b>Measurement/inspection results reviewed by:</b>	<b>B Oreb</b>

**10. Results**

	<b>Low Frequency Surface Errors (nm)</b>	
	<b>80 mm aperture</b>	<b>200 mm aperture</b>
<b>Surface 1</b>	0.6	0.7
<b>Surface 2</b>	0.6	0.9

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*



<b>1</b>	<b>Substrate Type:</b>	<b>Beamsplitter</b>
<b>2</b>	<b>Serial Number:</b>	<b>BS03-B</b>
<b>3</b>	<b>Physical quantity certified:</b>	<b>Surface Errors - high spatial frequency</b>
<b>4</b>	<b>LIGO specification reference:</b>	<b>E960100-B-D</b>
<b>5</b>	<b>CSIRO measurement/inspection procedure reference:</b>	<b>HABA-LIGO-M-SH-A</b>
<b>6</b>	<b>Variations to the measurement/inspection procedure:</b> (indicate Yes/No and attach separate sheet if Yes)	<b>Data were analysed using PC-based software routines rather than HP-based routines.</b>
<b>7</b>	<b>CSIRO Log Book Reference</b>	<b>LLN/091</b>
<b>8</b>	<b>Team member responsible for measurement/inspection:</b>	<b>F Lesha</b>
<b>9</b>	<b>Measurement/inspection results reviewed by:</b>	<b>C Walsh</b>

**10. Results**

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

**Side 1:            0.20**

**Side 2:            0.23**

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

**Side 1:            0.20**

**Side 2:            0.26**

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

	<b>A</b>	<b>B</b>	<b>C</b>	<b>D</b>	<b>E</b>	<b>F</b>	<b>G</b>	<b>H</b>
<b>Surface 1</b>	<b>0.20</b>	<b>0.17</b>	<b>0.20</b>	<b>0.21</b>	<b>0.20</b>	<b>0.20</b>	<b>0.18</b>	<b>0.22</b>
<b>Surface 2</b>	<b>0.21</b>	<b>0.25</b>	<b>0.24</b>	<b>0.22</b>	<b>0.24</b>	<b>0.39</b>	<b>0.29</b>	<b>0.23</b>

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:

19 June 98

# T2BS31A.25C

BS31A1

Time: 4:48

Date: 5/14/98

RMS: 0.217nm

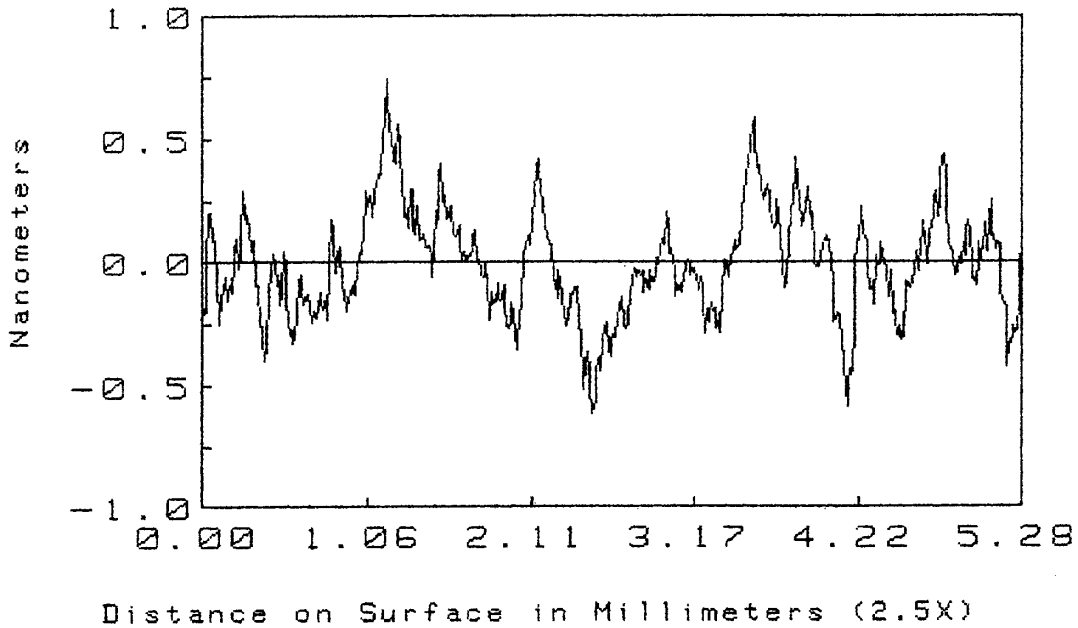
PROFILE

PV: 1.35nm

RA: 0.170nm

Ref. Subtracted

RC: 13.3 km



Att. 3

WYKO

# T2BS31B.25C

BS31B1

Time: 4:52

Date: 5/14/98

RMS: 0.213nm

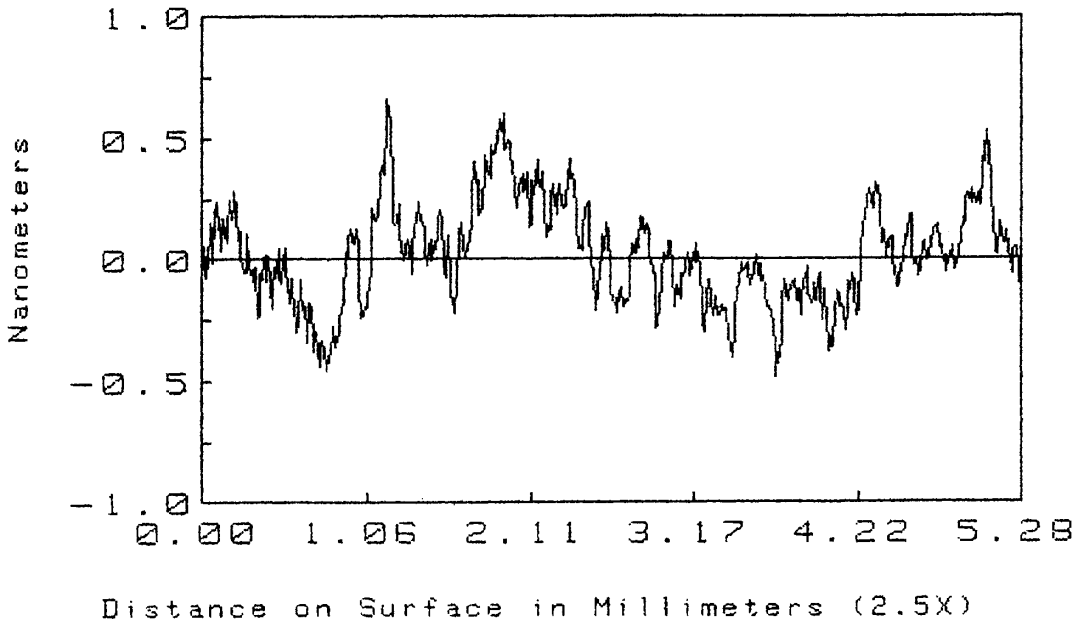
PROFILE

PV: 1.19nm

RA: 0.170nm

Ref. Subtracted

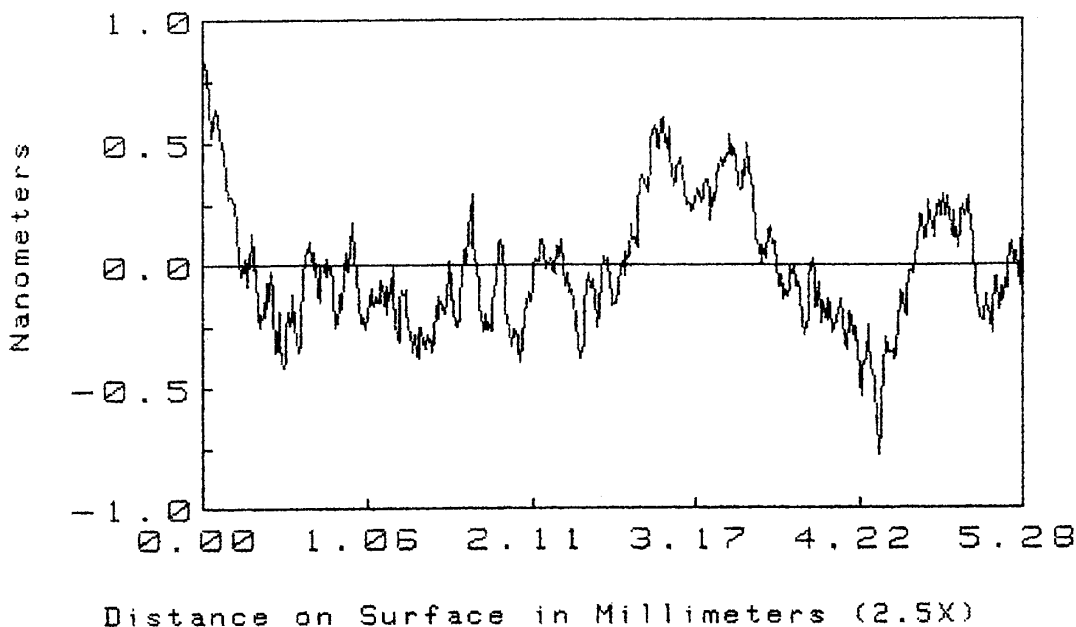
RC: 9513 m



WYKO

# T2BS31C.asc

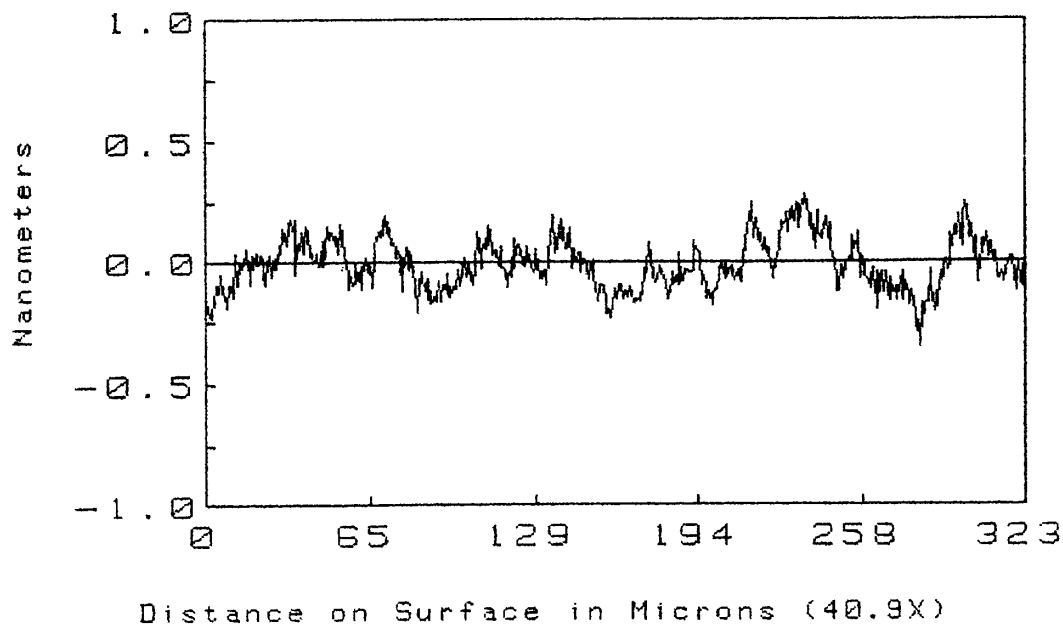
BS31C1                      Time: 4:55                      Date: 5/14/98  
RMS: 0.262nm                      PV: 1.64nm  
RA: 0.209nm                      Ref. Subtracted                      RC: -6861 m



WYKO

# T2BS31A.asc

BS31A4                      Time: 12:18                      Date: 5/15/98  
RMS: 0.107nm                      PV: 0.654nm  
RA: 0.086nm                      Ref. Subtracted                      RC: -132 m



WYKO

# T4BS31B.asc

BS31B4

Time: 13:55

Date: 5/15/98

RMS: 0.126nm

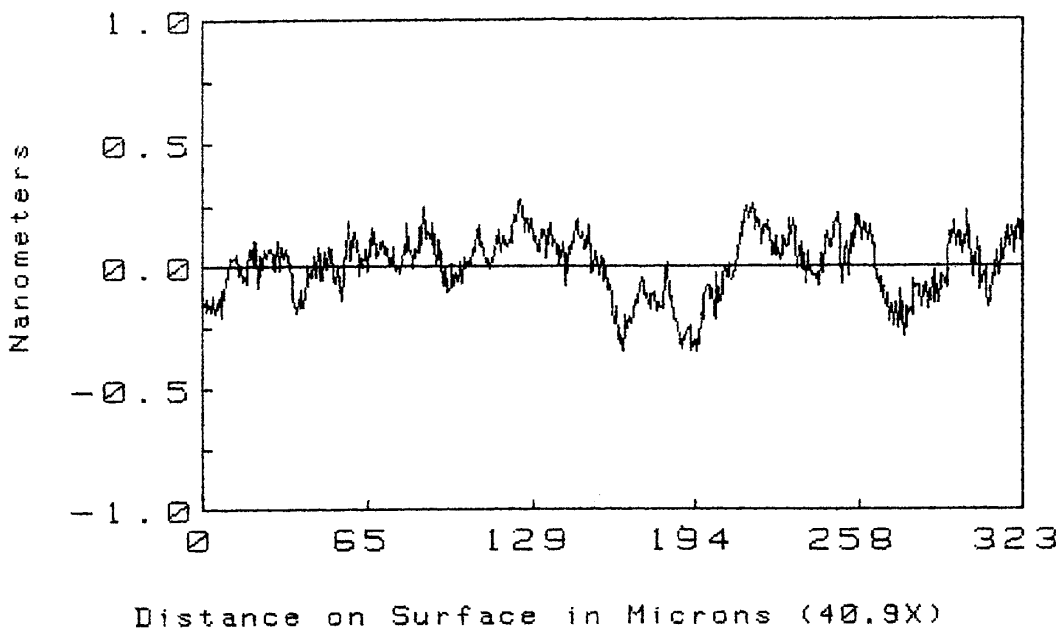
PV: 0.644nm

RA: 0.102nm

Ref. Subtracted

RC: -138 m

PROFILE



WYKO

# T4BS31C.asc

BS31C4

Time: 13:59

Date: 5/15/98

RMS: 0.146nm

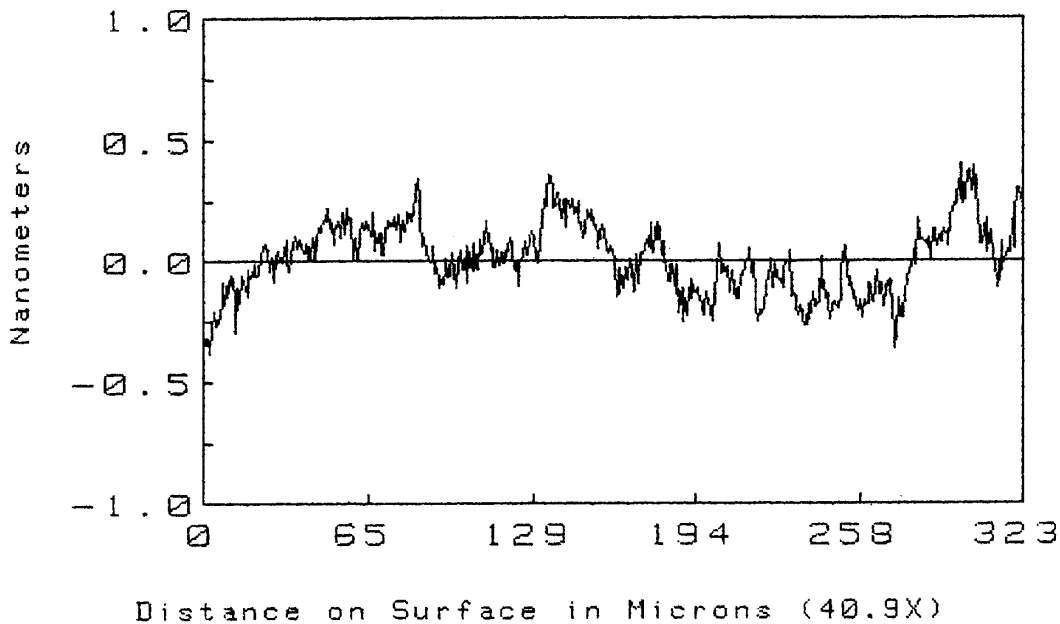
PV: 0.930nm

RA: 0.117nm

Ref. Subtracted

RC: 29.5 m

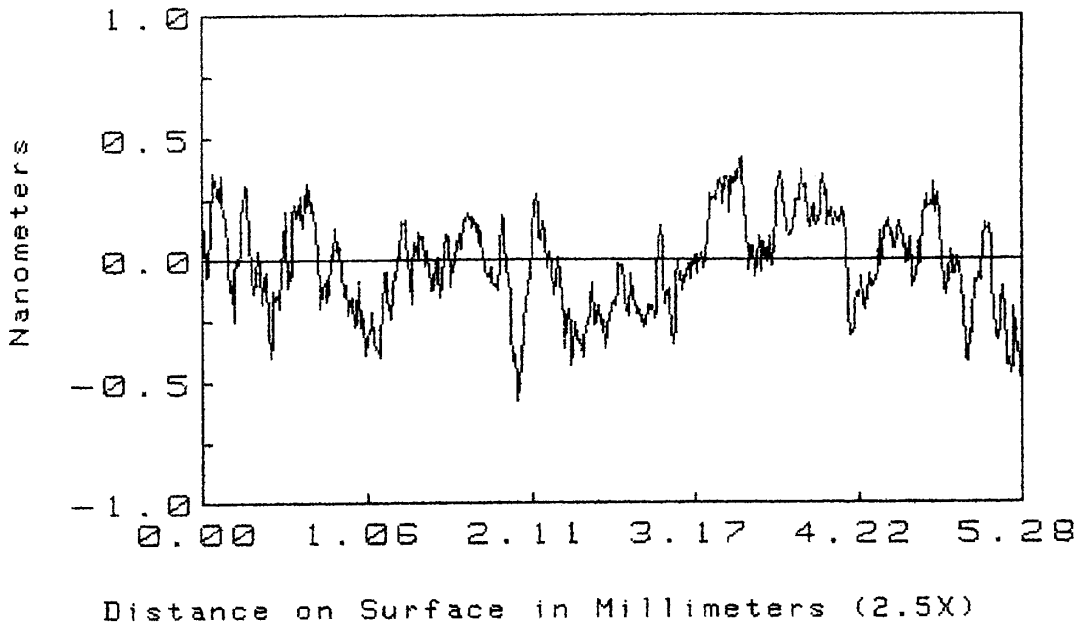
PROFILE



WYKO

# T2BS32A.asc

BS32A1 Time: 15:32 Date: 5/11/98  
RMS: 0.202nm Ref. Subtracted PV: 1.04nm  
RA: 0.166nm RC: 6538 m

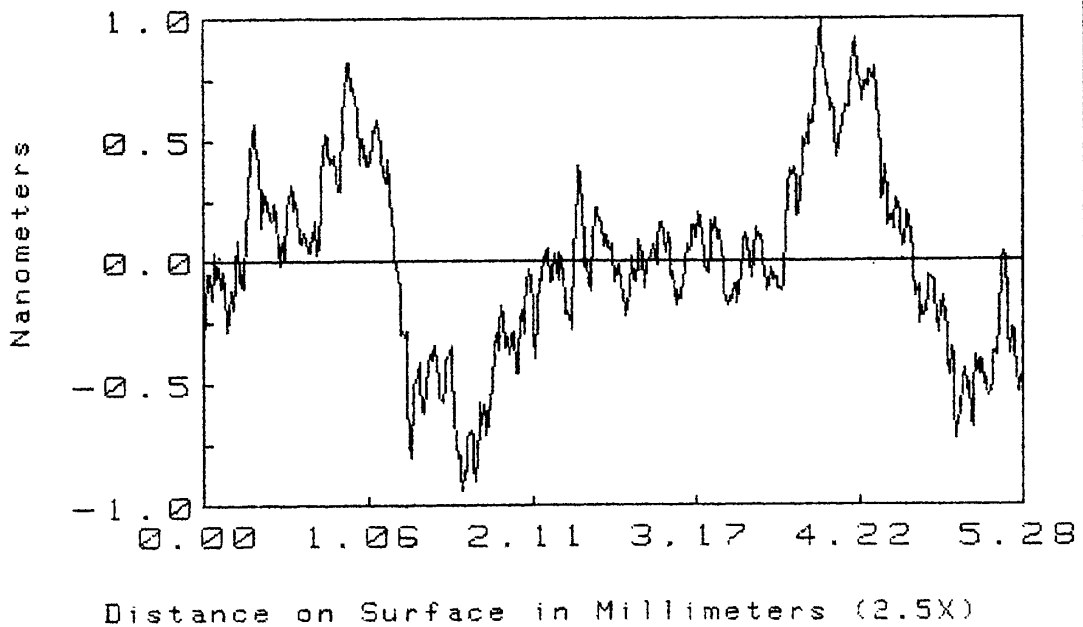


Att. 4

WYKO

# T2BS32B.asc

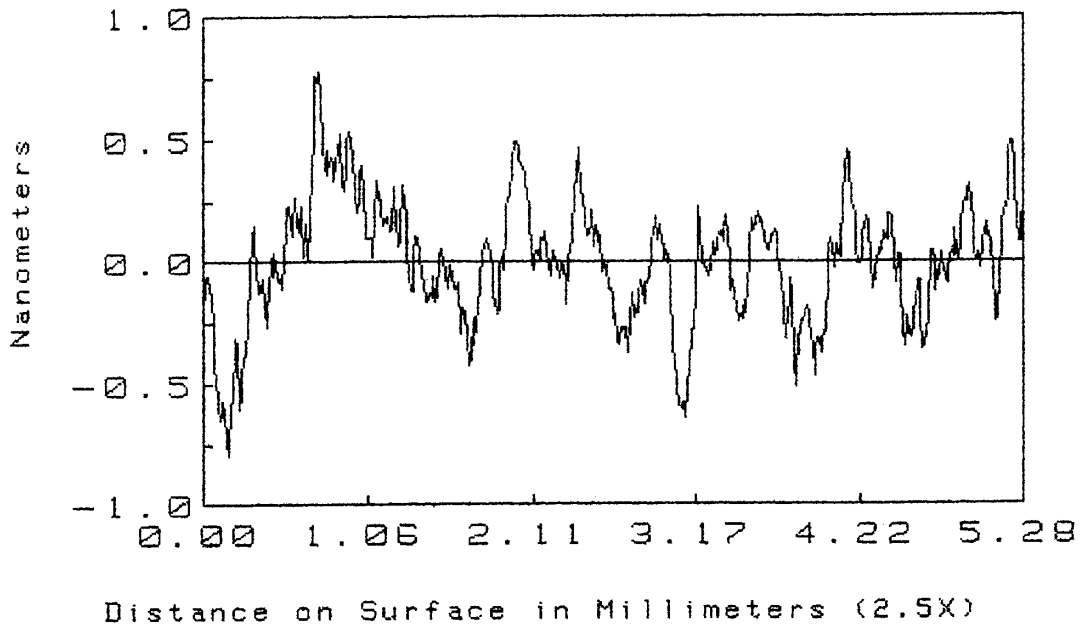
BS32B1 Time: 15:39 Date: 5/11/98  
RMS: 0.388nm Ref. Subtracted PV: 1.96nm  
RA: 0.302nm RC: 6268 m



WYKO

# T2BS32C.asc

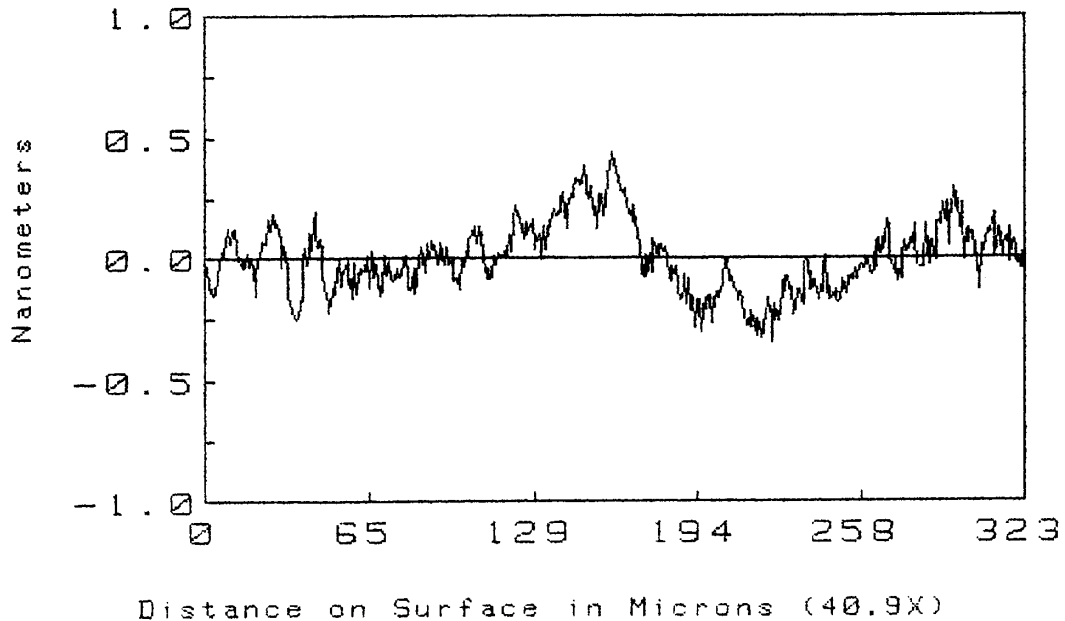
BS32C1                      Time: 15:47                      Date: 5/11/98  
RMS: 0.251nm                      PV: 1.58nm  
RA: 0.192nm                      Ref. Subtracted                      RC: 21.6 km



WYKO

# T4BS32A.asc

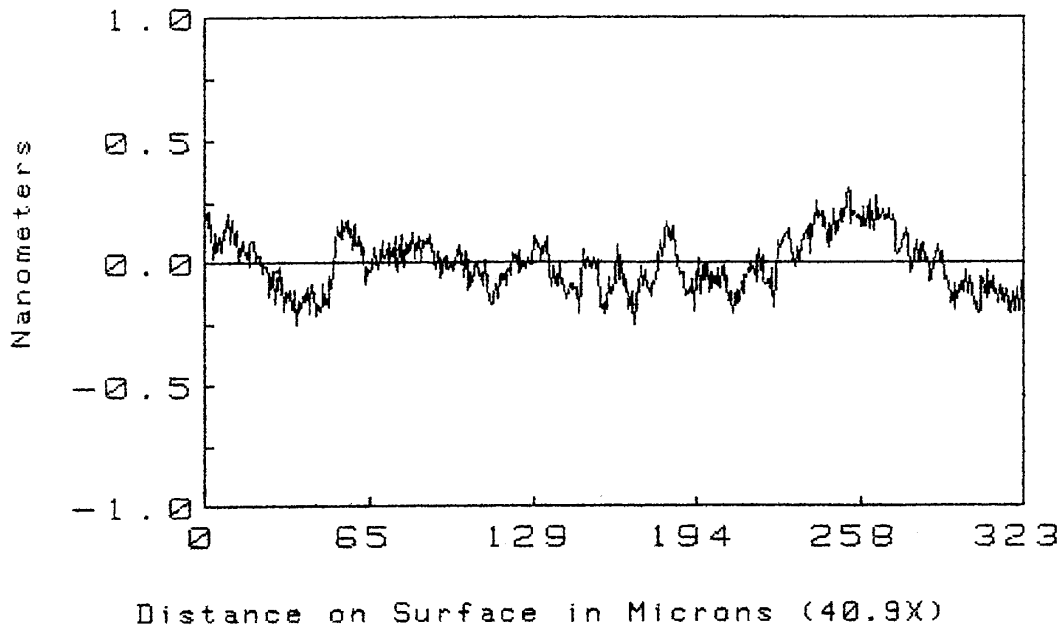
BS32A4                      Time: 3:15                      Date: 5/12/98  
RMS: 0.144nm                      PV: 0.825nm  
RA: 0.114nm                      Ref. Subtracted                      RC: -369 .m



WYKO

# T4BS32B.asc

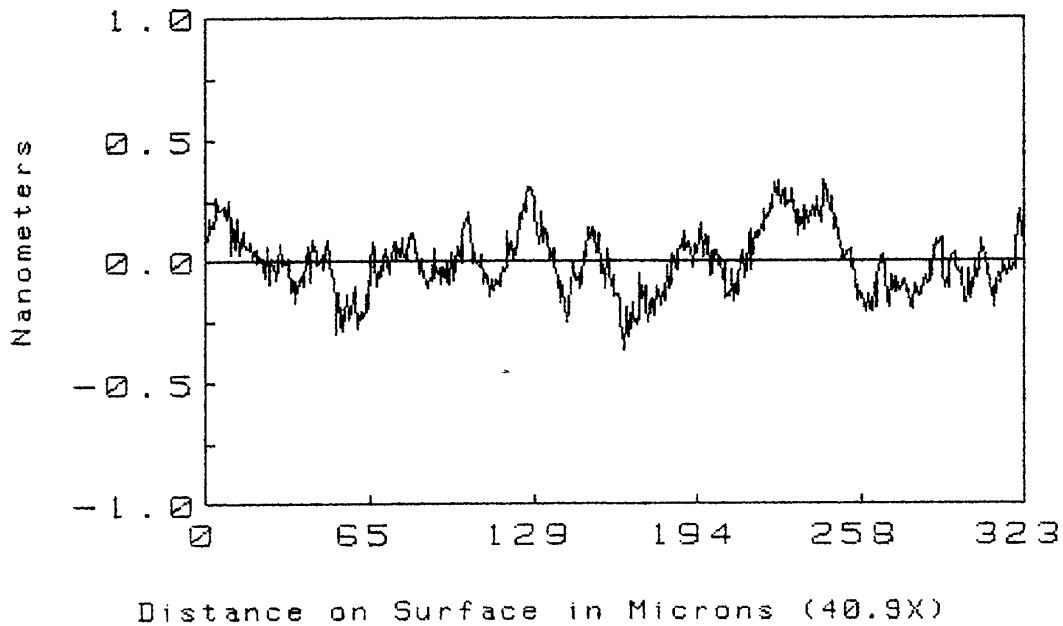
BS32B4 Time: 3:19 Date: 5/12/98  
RMS: 0.114nm Ref. Subtracted PV: 0.625nm  
RA: 0.094nm RC: -29.1 m



WYKO

# T4BS32C.asc

BS32C4 Time: 3:22 Date: 5/12/98  
RMS: 0.134nm Ref. Subtracted PV: 0.751nm  
RA: 0.107nm RC: 32.3 m



WYKO





Research Electro-Optics Inc.

# CERTIFICATE OF CONFORMANCE

Section 3.14/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 : 31 July 98
- Customer Name, Purchase Order No. : LIGO / Caltech
- Customer Part Number & Revision : Ligo - E980069-00-D
- Part Description : Beam splitter, 25 cm dia.
- REO Job No. : CPT05831-22 Run No.: OX779 - Beam splitter  
OX783 - AR
- Qty. Shipped/Lot No. : 1 ea B503 1 ea 1" dia. witness  
1 ea B504

Test data (included)

Comment:

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

Certified by: , 7/31/98  
Quality Assurance

Verified by: , 31 July 98  
Engr/Tech

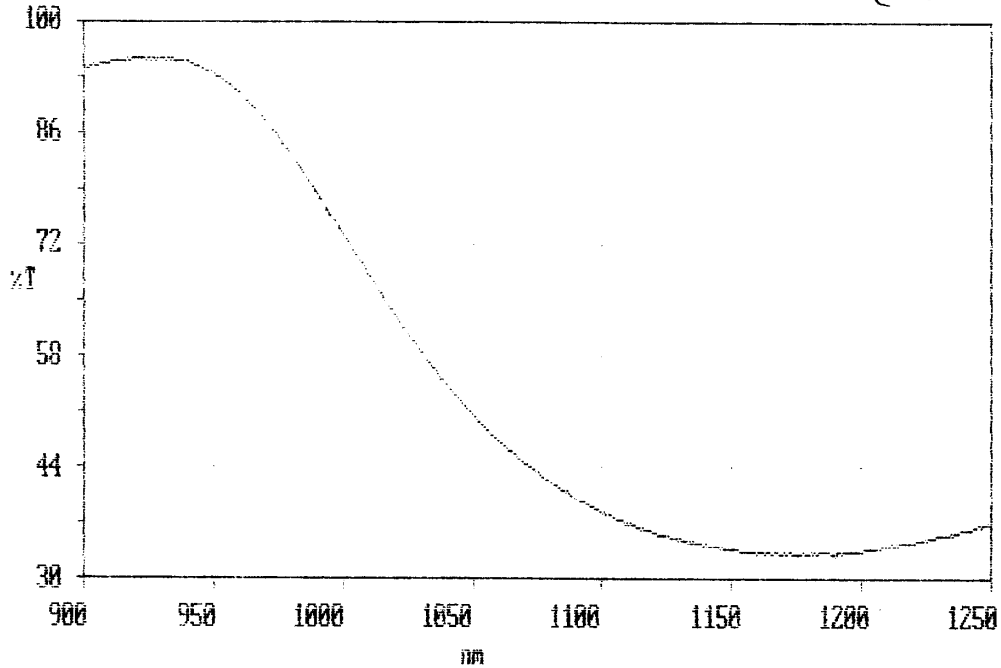
**NOTE**

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.

BS03-B

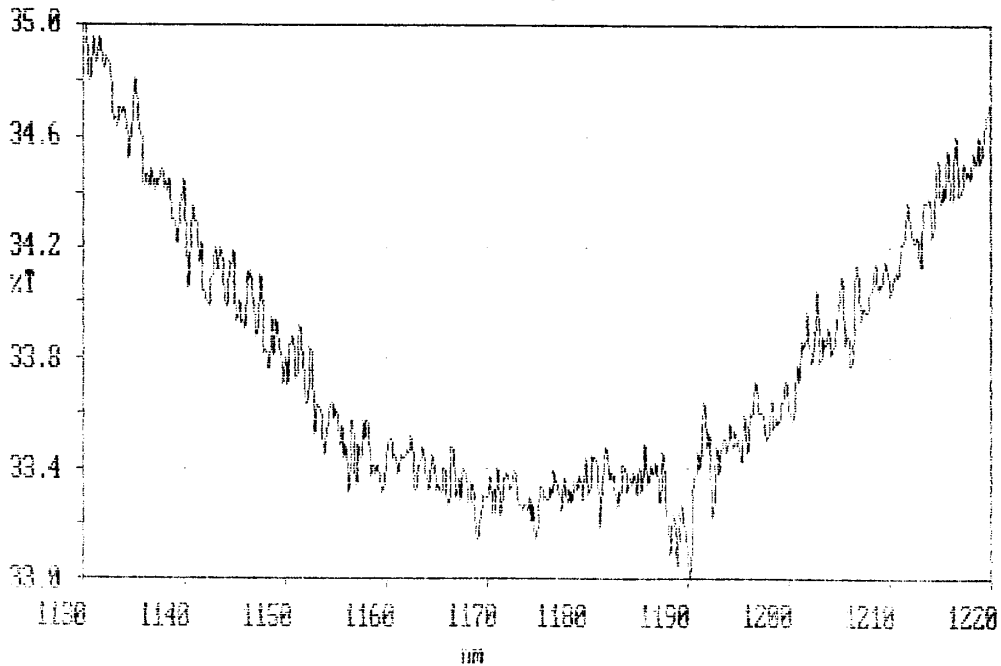
X: user004; 1250.0 - 900.0 nm; pts 3501; int 0.10; ord 33.000 - 95.705 %T

Inf: #0X779, FS witness for BS03, BS04. Baked, normal incidence scan (S2 Not Coated)



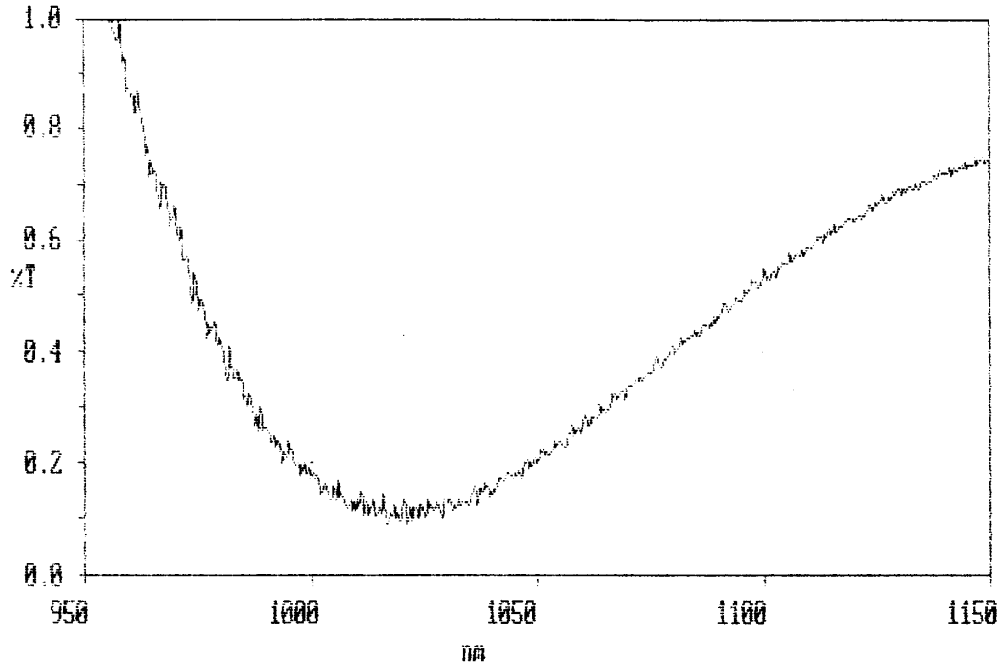
X: user004; 1250.0 - 900.0 nm; pts 3501; int 0.10; ord 33.000 - 95.705 %T

Inf: #0X779, FS witness for BS03, BS04. Baked, normal incidence scan



BS03-B (~~BS03-B~~)

X: user022; 1150.0 - 950.0 nm; pts 1001; int 0.20; ord 0.0891 - 1.2753 %T  
Inf: #0X783, AR for BS03 and BS04, after bake, normal incidence



X: user022; 1150.0 - 950.0 nm; pts 1001; int 0.20; ord 0.0891 - 1.2753 %T  
Inf: #0X783, AR for BS03 and BS04, after bake, normal incidence

