# BS04-B

## LIGO-T990137-00-D

BLANK

**A. DCN: LIGO-** T970203-00-D **LIGO DETECTOR OPTICS** 

**B. LIGO S/N:** BS04 **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 8965

**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: Steve Vigen Date Inspected: 12-02-97

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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.

S/N not correctly marked - wrong serial number

OH content not reported

**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: BSØ4 | | Specification | Reported Value | ✓ |
|---|---|---|---|---|---|
| | Requirements | Physical Dimensions | LIGO-D960793-B | | ✓ |
| | | Diameter | 256mm +1.0mm, -0mm | 256.7 mm | ✓ |
| | | Thickness | 52 ~~61~~mm +1.0mm, -0mm | 52.84mm | ✓ |
| | | Chamfer | 2.0mm Max 2pl | | |
| | | Clear Aperture | Central 235mm | | |
| | | Material | Fused Silica Suprasil ~~#7980~~ 3115 | 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 | $\leq 5.0 \times 10^{-7}$ 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. | ✓ |
| | | 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 8965 |
| **Marking** | : 960095-IM 16 - B504 BN 5C 6C |

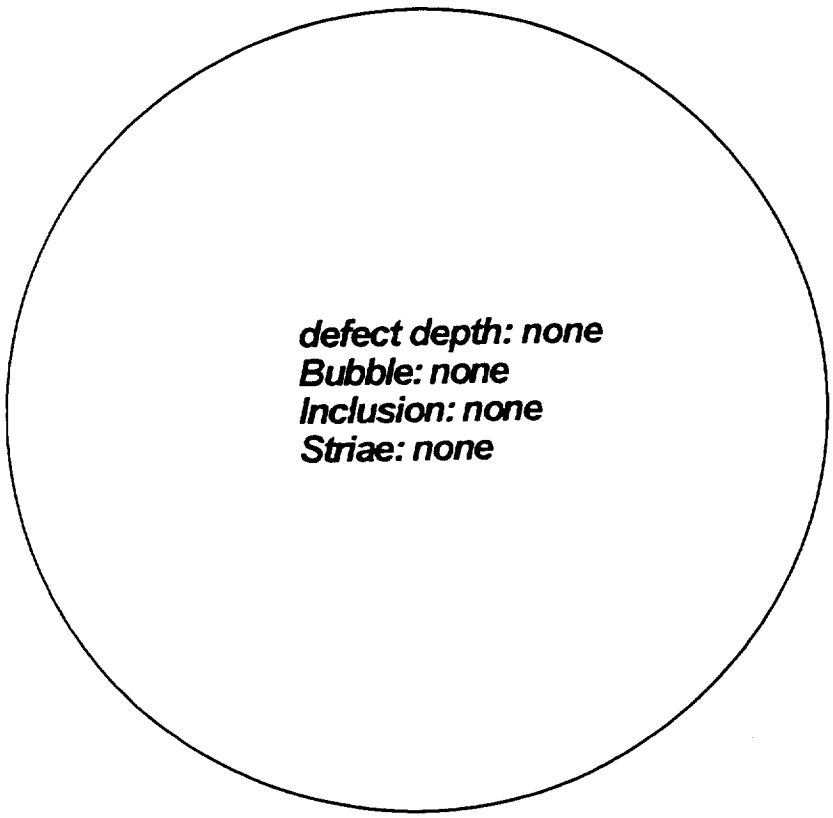
| | | |
|---|---|---|
| **Diameter** | | : 256,7mm |
| **CA Diameter** | | : Ø 200 mm = 0,74xE$^{-6}$ |
| **Thickness** | | : 52,84 mm |
| **Edge** | | : 0,3 - 0,5 mm |
| **Parallelism** | | : 0,08 mm |
| **Roughness** | | : ground |
| | $R_a$ | : 1,08 µm |
| | $R_t$ | : 8,86 µm |
| **Bubble class** | | : 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<br>POL- QW | Order Nr.: 94908401 Pos.: 2<br>Ø 256,7 mm x 52,84 mm<br>Quality: Suprasil 311<br>Plate No.: 960095-IM16/5060 | Date: 6.10.97<br>Inspector: |
|---|---|---|

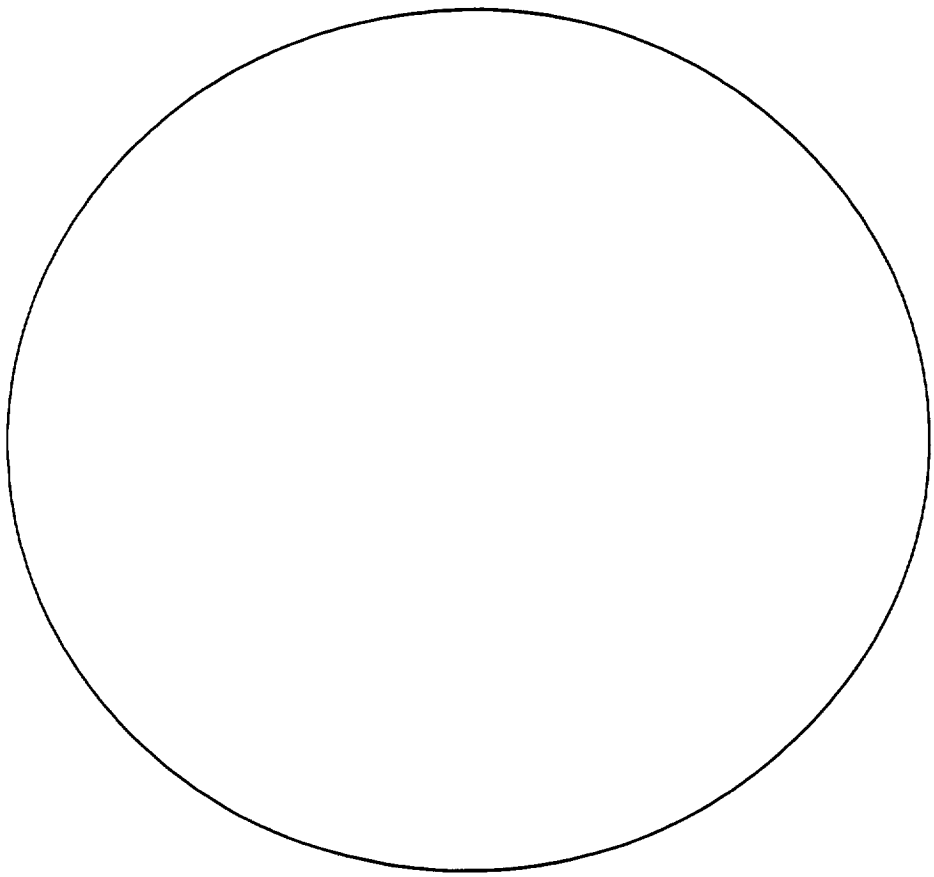



| Diameter | 0,03mm | 0,05mm | 0,08mm | 0,12mm | 0,2mm | 0,31mm | Sum |
|---|---|---|---|---|---|---|---|
| piece | | | | | | | |
| $mm^2$ | | | | | | | |

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

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

| Heraeus QUARZGLAS<br>POL - QW | Order No.: 94908401 Pos.: 2<br>Ø 256,7 mm x 52,84 mm<br>Plate No.: 960095-1M16/5060<br>Residual strain- Report | Date: 6.10.97<br>Inspector: |
|---|---|---|

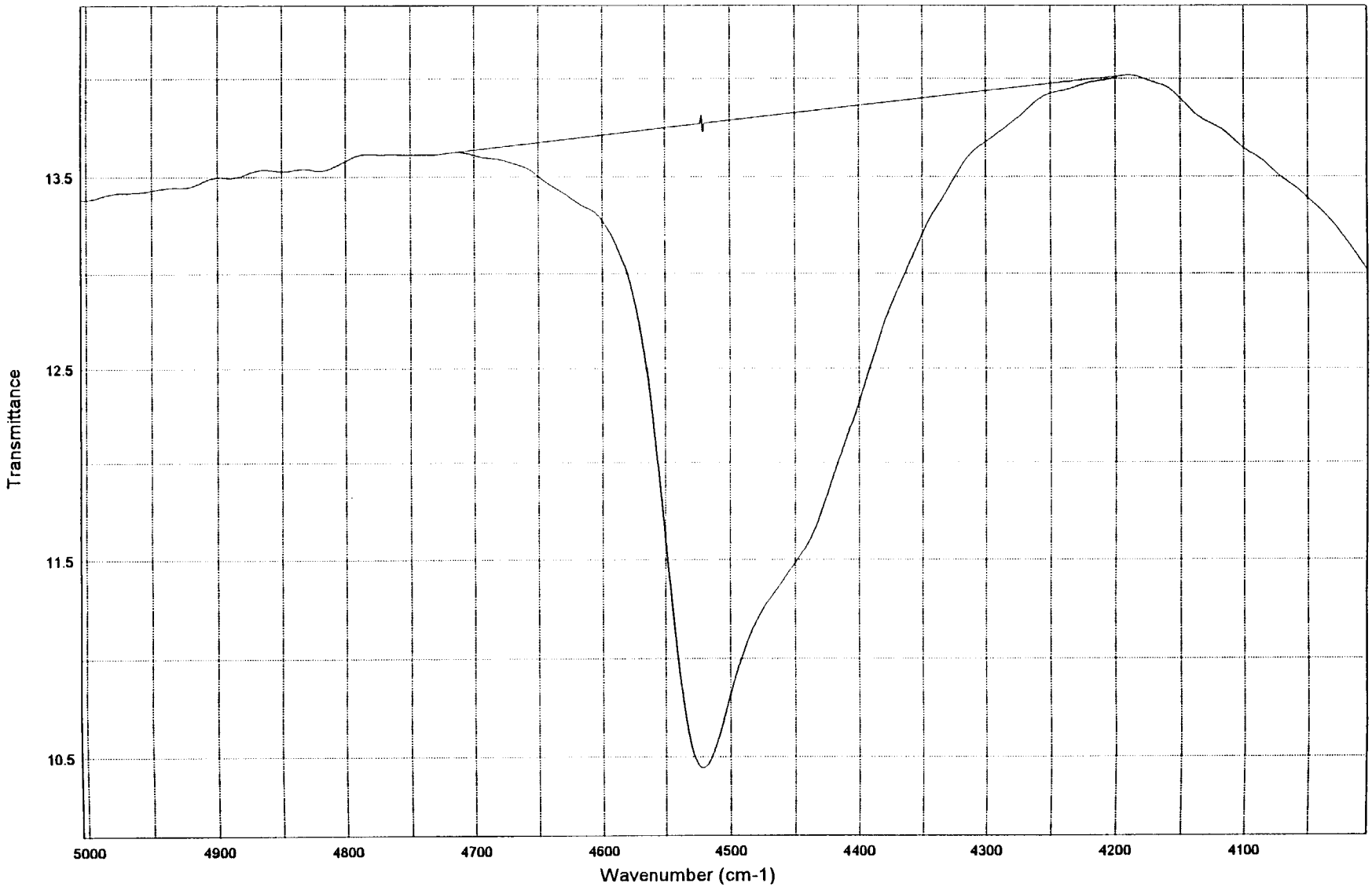


| Edge | Center | | | | | | Pos. |
|---|---|---|---|---|---|---|---|
| 10 | | | | | | | nm |
| 2 | <1 | | | | | | nm/cm |

I0=13.7711 , I1=10.4409 at x=4521 OH-content: 202.7 ppm

Heraeus
QUARZGLAS

MEASURE NO. : 5060
DATE : 05.09.1997 TIME : 12:27
MEASURE START : 10000 1/cm
MEASURE END : 2500 1/cm
OP-DISK-PATH LENGTH : Ko-203-PL: 2.61 cm / Order No.: 9930 3974 / Material: 5060-----OH-content: 202.7 ppm at x=4521



Heraeus
QUARZGLAS

# POL-QW

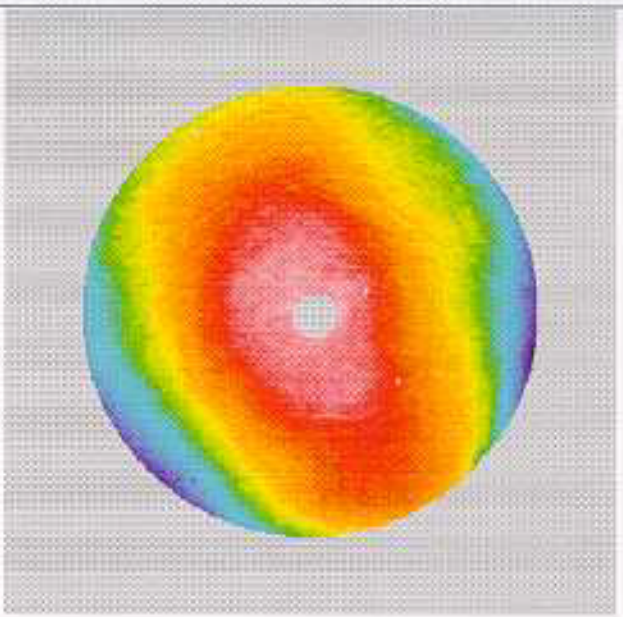
Data taken at 632.8 nm

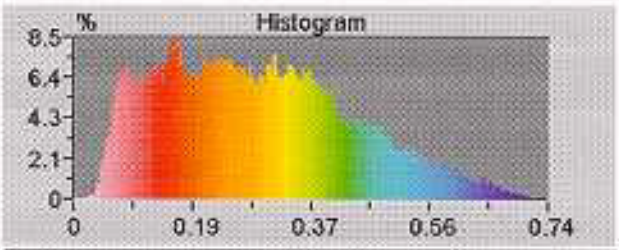
Date: 04.09.97 Operator: RI
ID: 506000 No.:

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: 59729



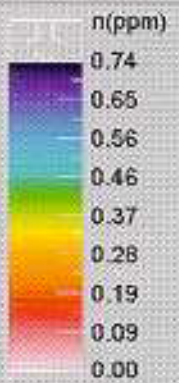



| Sub. Terms | | Magn. | Angle |
|---|---|---|---|
| X | Tilt | 0.1048 | -16.7039 |
| | Focus | 0.2116 | |
| | Astigm. | 0.1771 | -67.7109 |
| | Coma | 0.0230 | 52.3769 |
| | SA3 | -0.0142 | |

Phase Data

| | |
|---|---|
| Unit | n(ppm) |
| PV: | 0.74 |
| RMS: | 0.146 |
| Scale: | 0.5 |

Contrast




Reset

| | |
|---|---|
| UpperL | 0.740 |
| LowerL | 0.000 |

File: 506000.dat, 04.09.97, 18:12

XPS-12"

BSØ4

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<br>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.<br><br>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.<br><br>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.<br><br>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

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<br>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.<br><br>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.<br><br>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.<br><br>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-** T790203-01-D
**B. LIGO S/N:** [redacted] BS04-B

**LIGO DETECTOR OPTICS**
**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: 10-01-98

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 | _____ in | 250.97 | mm |
| ☑ | Inspection of material thickness | Thickness | _____ in | 39.93 | 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.

Sent for repolish 8-14-98

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

Inspection By: _____ Date Inspected: 10-03-98

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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.)

Retuned to CSIRO for repolish (Bad coating)* - 8/14/98

* coating inspected by H. Armandula

**SKETCHES:**

**DISPOSITIONS:**

| Substrate, Beam Splitter | Serial Number: | | Specification | Reported Value | ✓ |
|---|---|---|---|---|---|
| | Surface 1 | Surface Figure Over Central 200mm dia. | Flat | | |
| | | Radius of Curvature | > 200 km convex<br>> 720 km concave | 905 Km<br>(5.6 nm) | ✓ |
| | | Astigmatism | < 16nm p-v | 7.3 nm | ✓ |
| | Surface 2 | Surface Figure Over Central 200mm dia. | Nominally Flat | | |
| | | Radius of Curvature of the Wavefront | > 140 km convex<br>> 500 km concave | 1034 Km<br>(5.0 nm) | ✓ |
| | | Astigmatism | < 23nm p-v | 3.6 nm | ✓ |
| | Surface Errors | Low Spatial Frequency Band Central 80mm | ≤ 4.3 $cm^{-1}$<br>$\sigma_{rms}$ < 1.6nm | 0.5 nm | ✓ |
| | | Low Spatial Frequency Band Central 200mm | ≤ 4.3 $cm^{-1}$<br>$\sigma_{rms}$ < 3.2nm | 0.8 nm | ✓ |
| | | High Spatial Frequency Band Central 80 & 200 mm | ≤ 4.3 – 7,500 $cm^{-1}$<br>$\sigma_{rms}$<0.4nm | 0.18 nm 0.18 nm | ✓ |

Wave front -195 Km (-25.5 nm)

| 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). < 5000 | Hand Sketch w/dimensions | ✓ |
| | | The total area of scratches outside the central 80 mm diameter shall not exceed 750 x $10^3$ square micrometers. < 15,000 | 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. | Inspection Report | ✓ |

# LIGO Component Specification Verification Sheet
# Beam Splitter

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

## Serial number: BS04-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: | BS4B1.zip | (Side 1) | BS4B2.zip | (Side 2) |
| | | | BS4B2A.zip | (wave front) |
| TOPO data: (2.5X) | T2BS41A.asc | (Side 1) | T2BS42A.asc | (Side 2) |
| | T2BS41B.asc | | T2BS42B.asc | |
| | T2BS41C.asc | | T2BS42C.asc | |
| (40X) | T4BS41A.asc | | T4BS42A.asc | |
| | T4BS41B.asc | | T4BS42B.asc | |
| | T4BS41B.asc | | T4BS42C.asc | |

| | | |
|---|---|---|
| 1 | **Substrate Type:** | **Beamsplitter** |
| 2 | **Serial Number:** | **BS04-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 $2\sigma$ of boundary of acceptability]

| Physical Quantity | Result |
|---|---|
| Diameter | 250.97 mm |
| Cylindricity | 0.01 mm |
| Thickness (maximum - for FM, RM, ETM)<br>(minimum - for BS) | <br>39.93 mm |
| Bevel as per drawing (height, angle): | (S1) Height: 2.07 mm Angle:$45^0$17'<br>(S2) Height: 2.03 mm Angle:$44^0$20' |
| 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$1', $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: 19 June 98

| | | |
|---|---|---|
| 1 | **Substrate Type:** | **Beamsplitter** |
| 2 | **Serial Number:** | **BS04-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: Chris Walsh

Date: 19 June 98

| | | |
|---|---|---|
| 1 | **Substrate Type:** | **Beamsplitter** |
| 2 | **Serial Number:** | **BS04-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:** | **BS04-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/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** | **<5,000** | **<15,000** |
| **Surface 2** | **nil** | **nil** | **nil** | **<20,000** |

**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

BSO4 Illinois

SIDE 1

5000

2000

5000 2500

500

500

1:2000

1:2000

BSC4

SIDE 2

1:2000

| | | |
|---|---|---|
| 1 | **Substrate Type:** | **Beamsplitter** |
| 2 | **Serial Number:** | **BS04-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 31-32** |
| 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** | **905 km (5.6 nm)** | **7.3** | BS4B1.zip |
| **Surface 2** | **1034 km (5.0 nm)** | **3.6** | BS4B2.zip |
| **Wave front*** | **-195 km (-25.5 nm)** | | BS4B2A.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 -25.5 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_41

Date: 06/01/98

Diameter: 200 mm

Astig: 7.3 nm

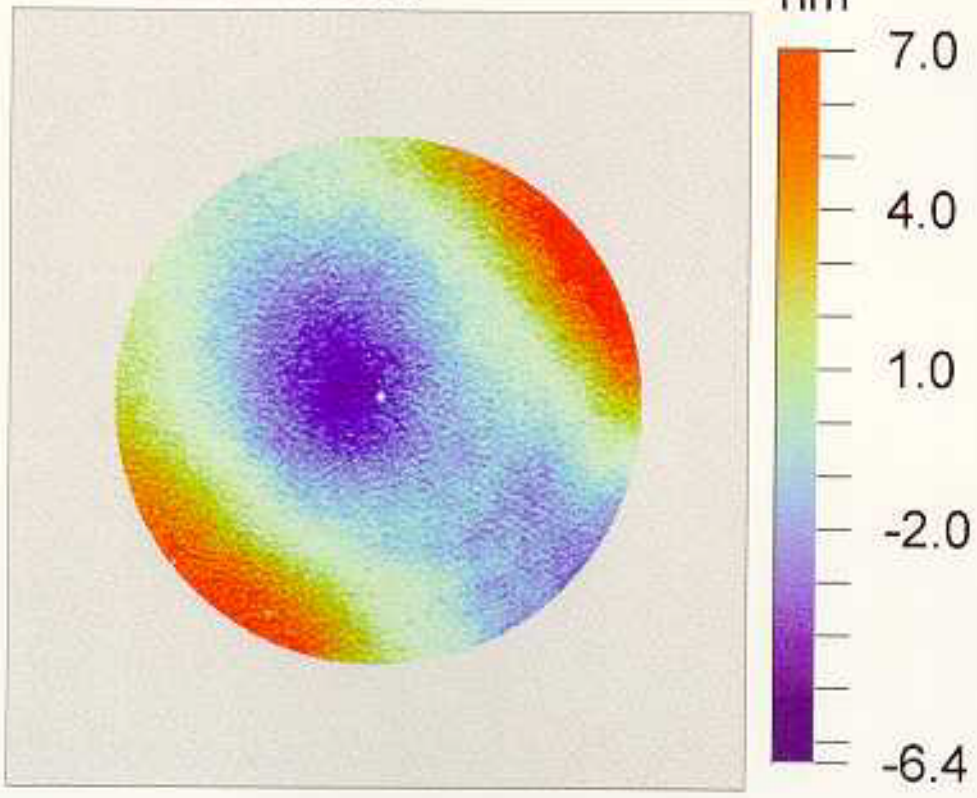
Power: 5.6 nm

CSIRO

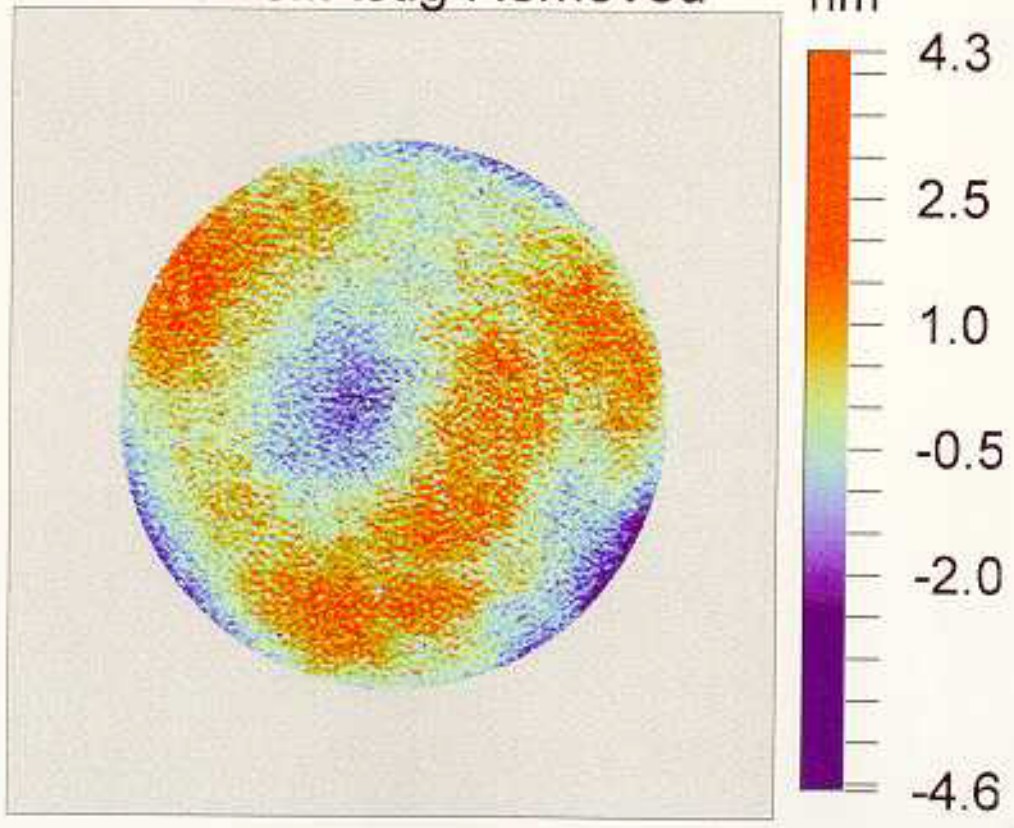
PV: 8.8 nm

RMS: 0.8 nm

Tilt Removed




Tilt/Power/Astig Removed




AH. 1

# LADI CERTIFICATION DATA

Title: BS_42

Date: 06/01/98

Diameter: 200 mm

Astig: 3.6 nm

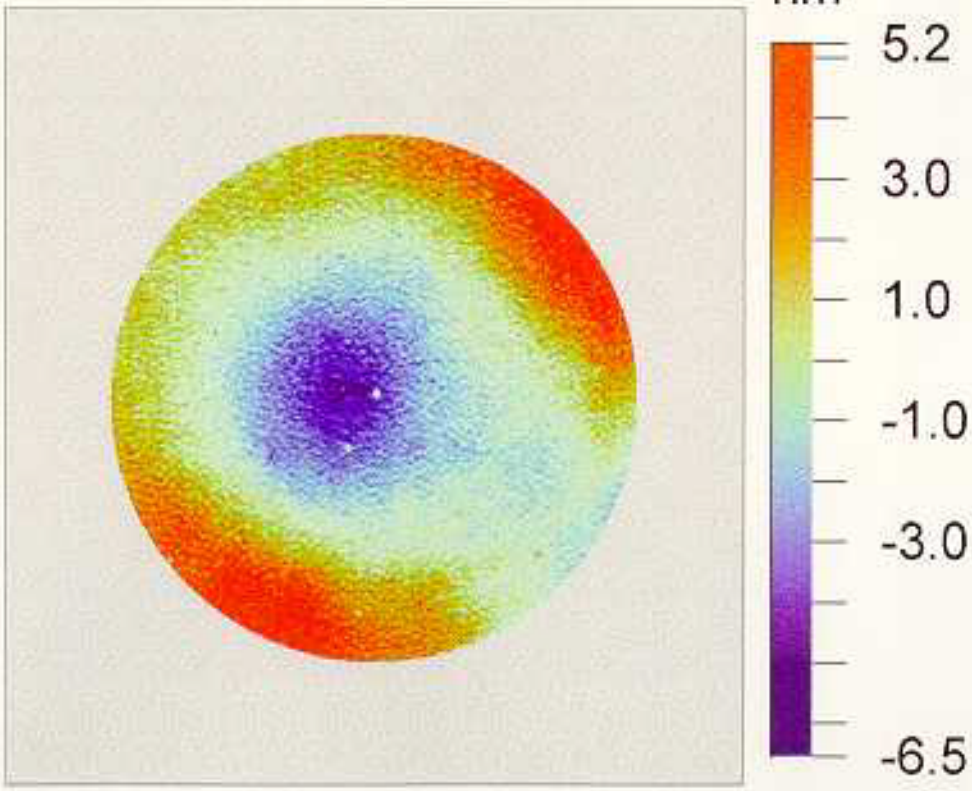
Power: 5.0 nm

CSIRO

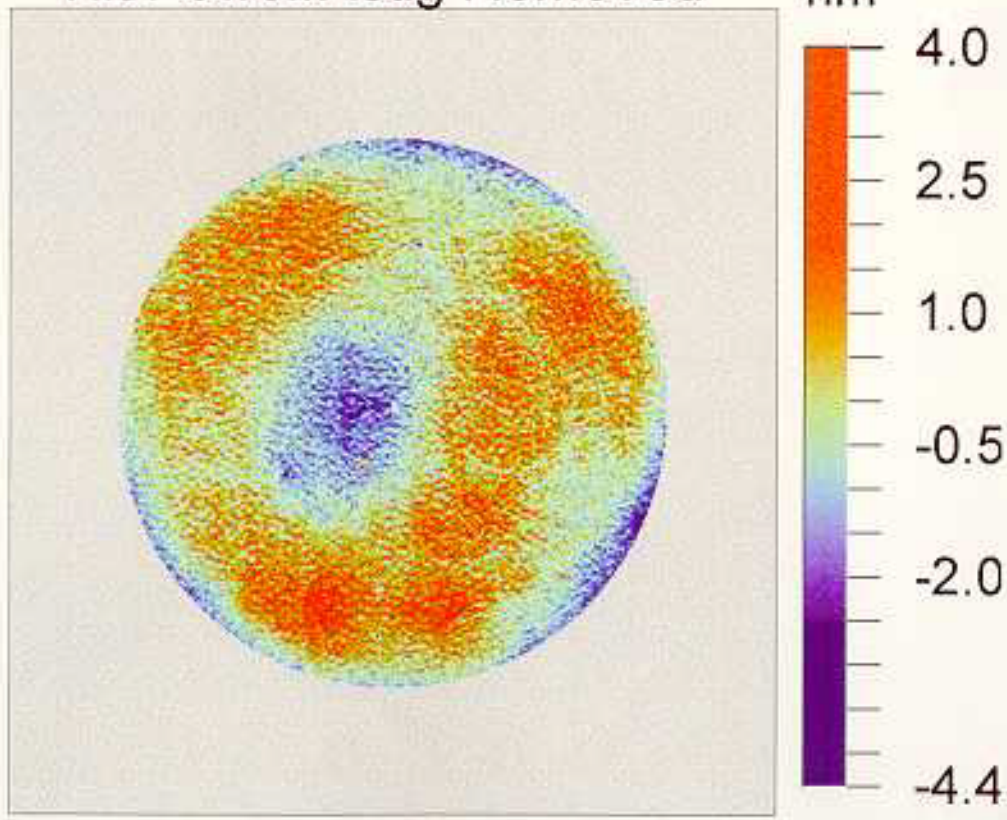
PV: 8.4 nm

RMS: 0.8 nm

Tilt Removed




Tilt/Power/Astig Removed




AH. 2A

# LADI CERTIFICATION DATA

Title: BS_4T

Date: 06/01/98

Diameter: 200 mm

Astig: -12.5 nm

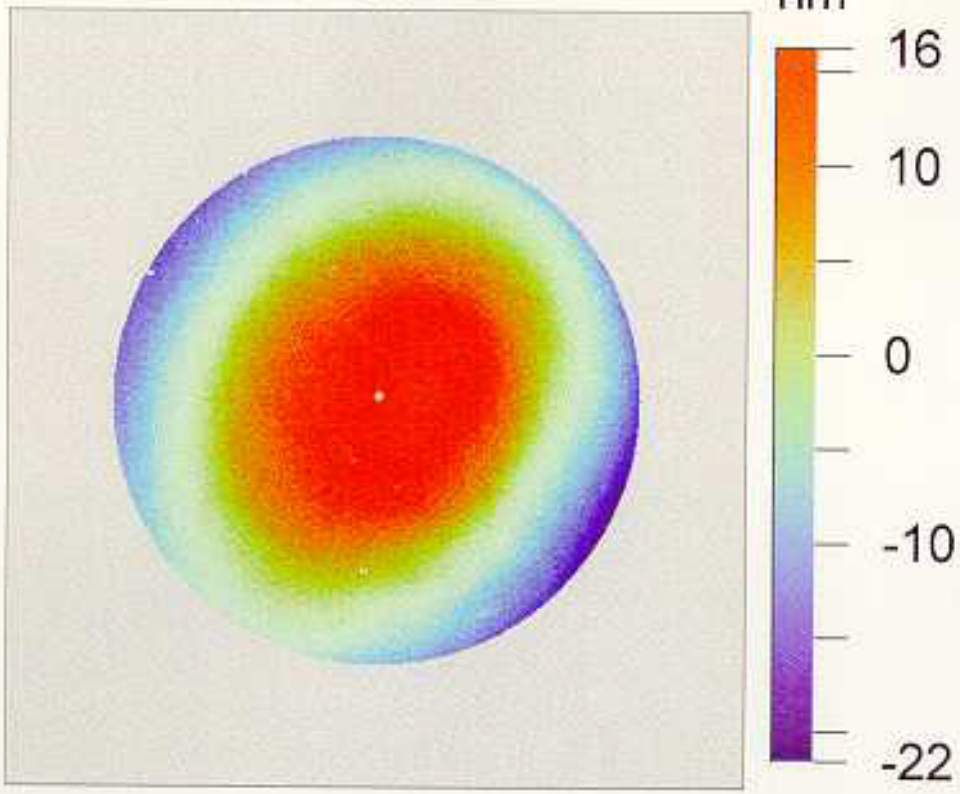
Power: -25.5 nm

CSIRO

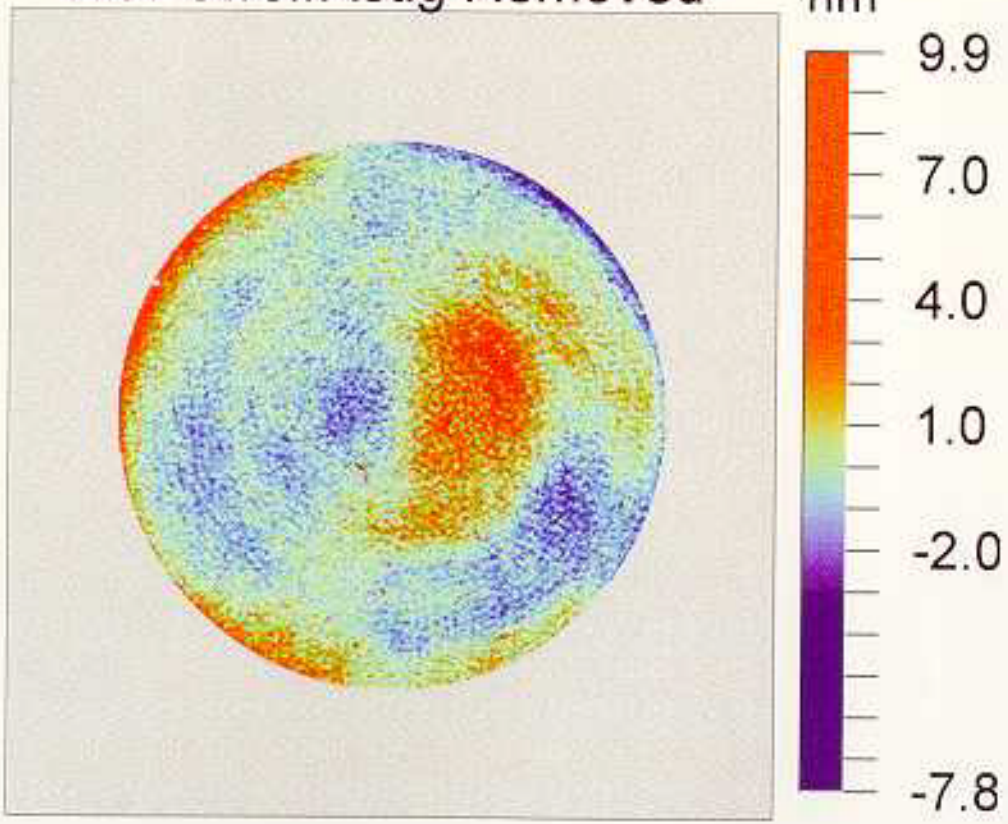
PV: 17.7 nm

RMS: 1.1 nm

Tilt Removed




Tilt/Power/Astig Removed




AH 28

| | | |
|---|---|---|
| 1 | **Substrate Type:** | **Beamsplitter** |
| 2 | **Serial Number:** | **BS04-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 31-32** |
| 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 | 0.8 |
| **Surface 2** | 0.5 | 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:** | **BS04-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:** **0.18**

**Side 2:** **0.19**

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

**Side 1:** **0.18**

**Side 2:** **0.19**

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

| | A | B | C | D | E | F | G | H |
|---|---|---|---|---|---|---|---|---|
| **Surface 1** | **0.17** | **0.18** | **0.20** | **0.19** | **0.18** | **0.17** | **0.18** | **0.20** |
| **Surface 2** | **0.18** | **0.19** | **0.18** | **0.19** | **0.21** | **0.21** | **0.20** | **0.18** |

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).

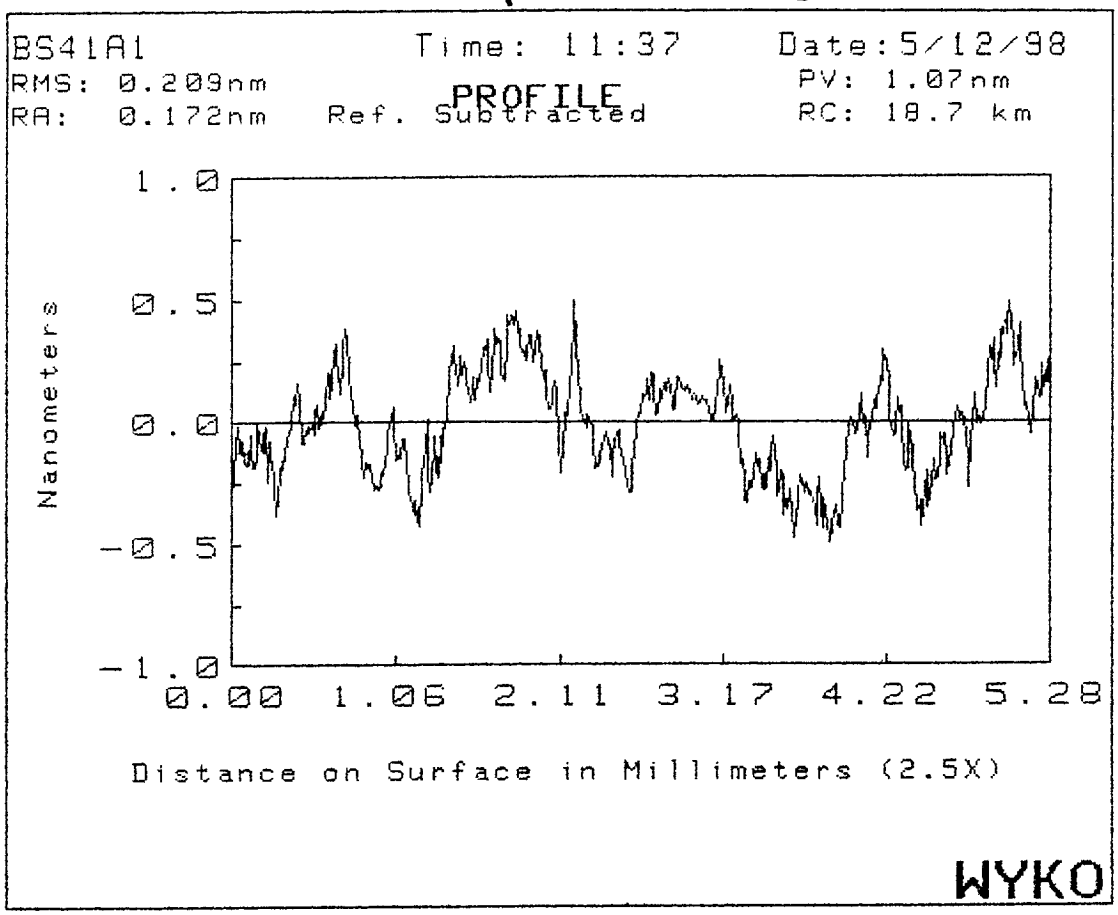
## 11. Certification

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

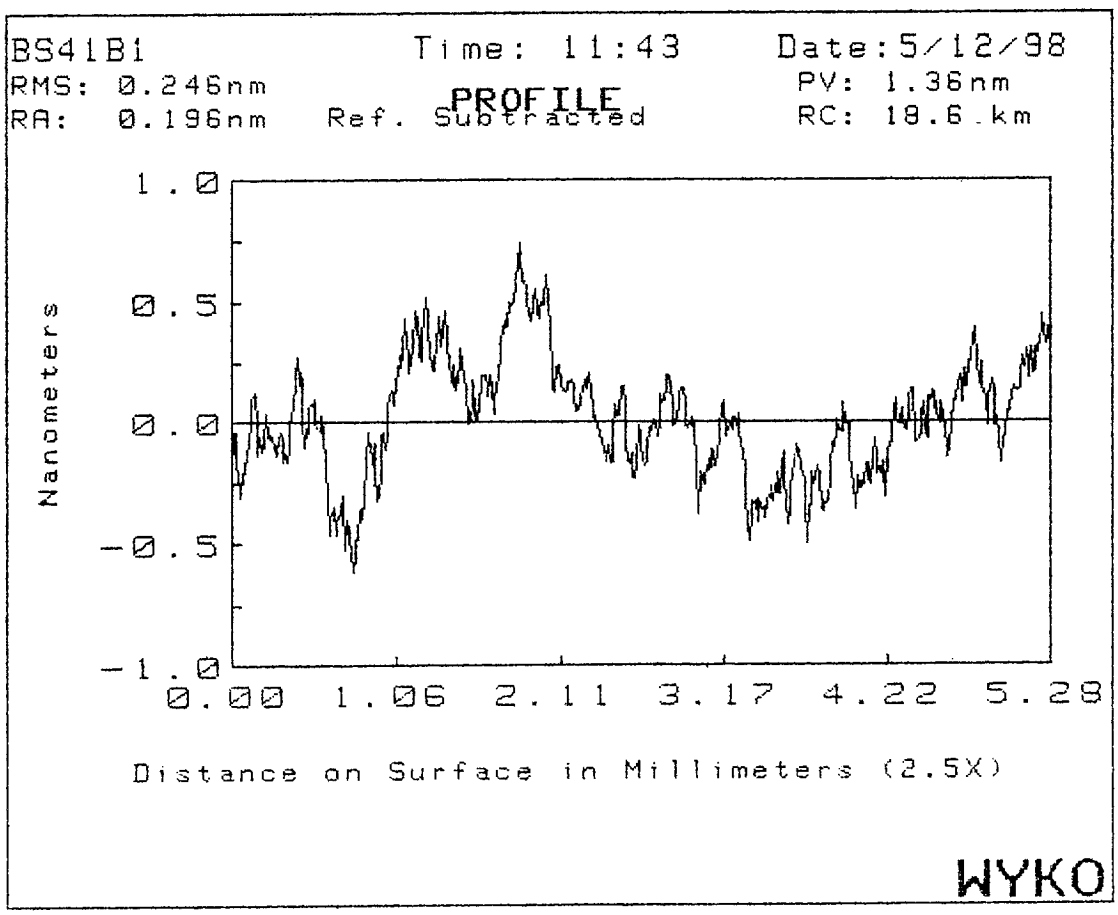
Date: 19 June 98

# T2BS41A.asc

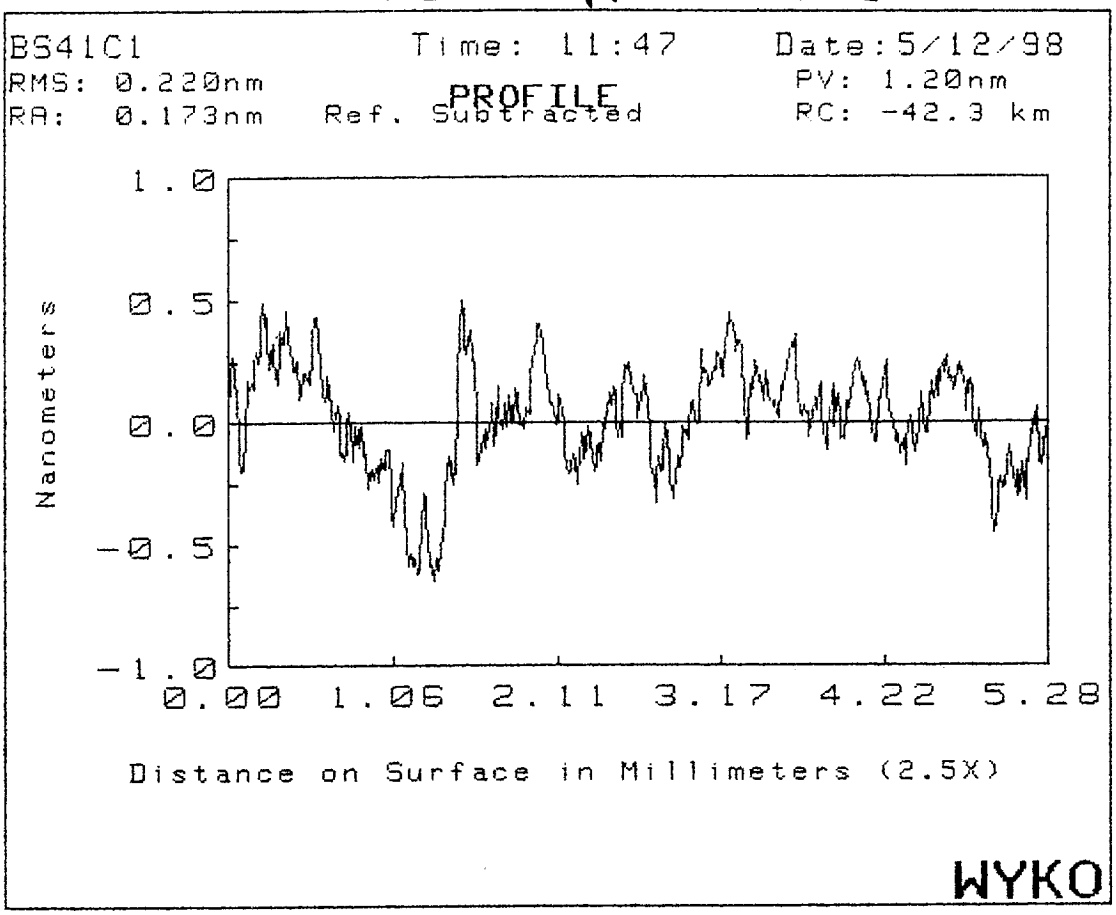



Att. 3

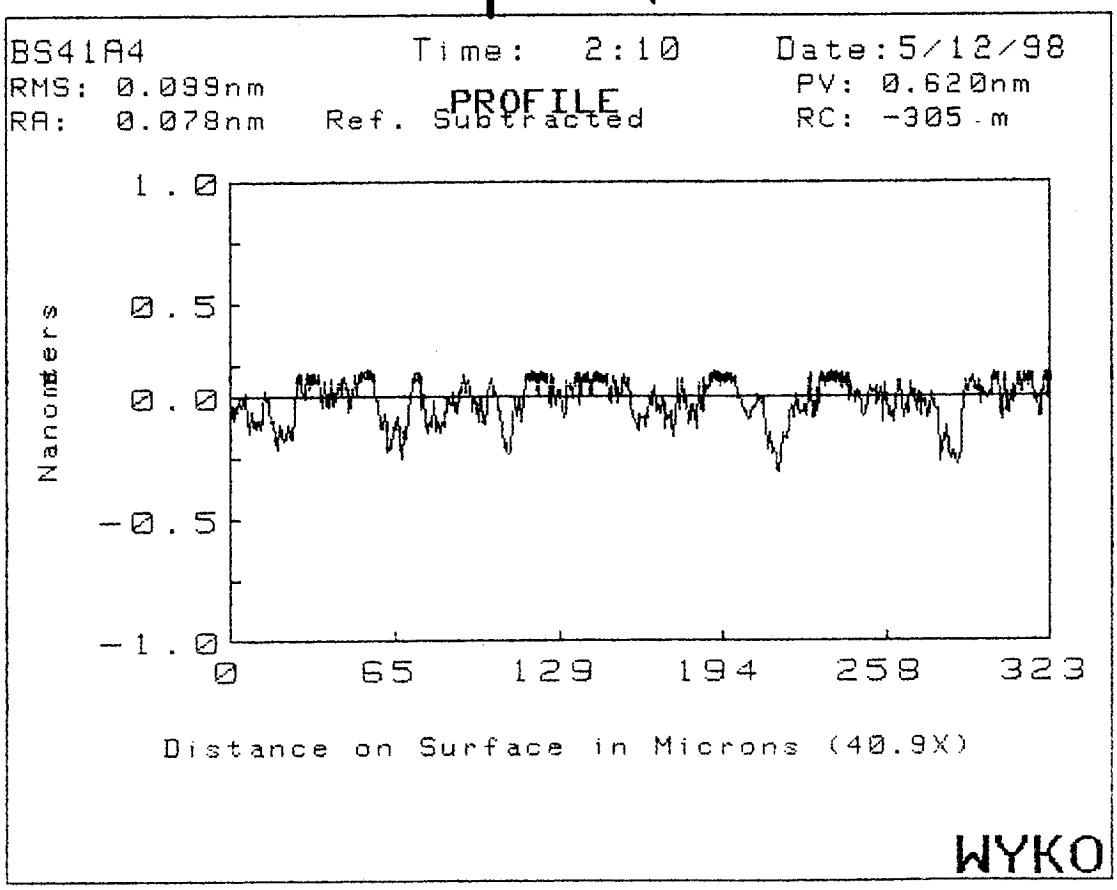
# T2BS41B.asc



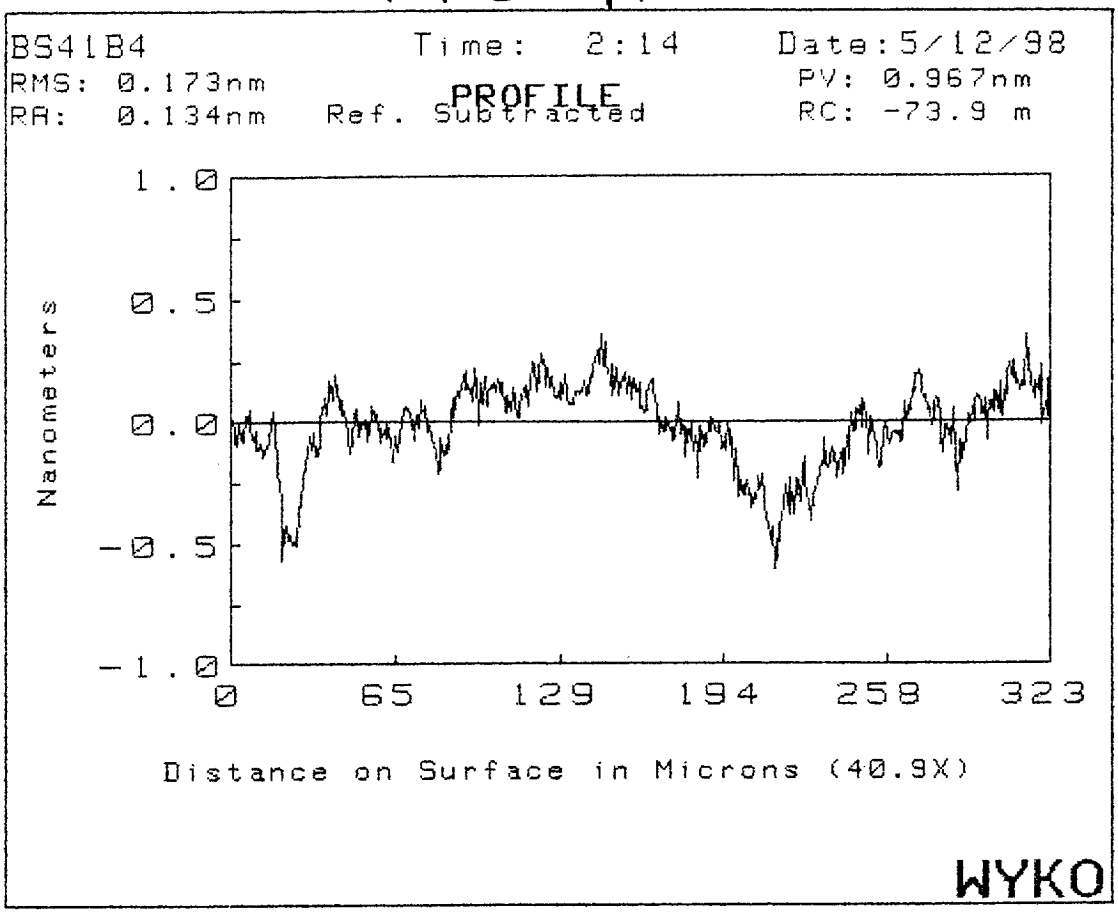
T2BS41C.asc



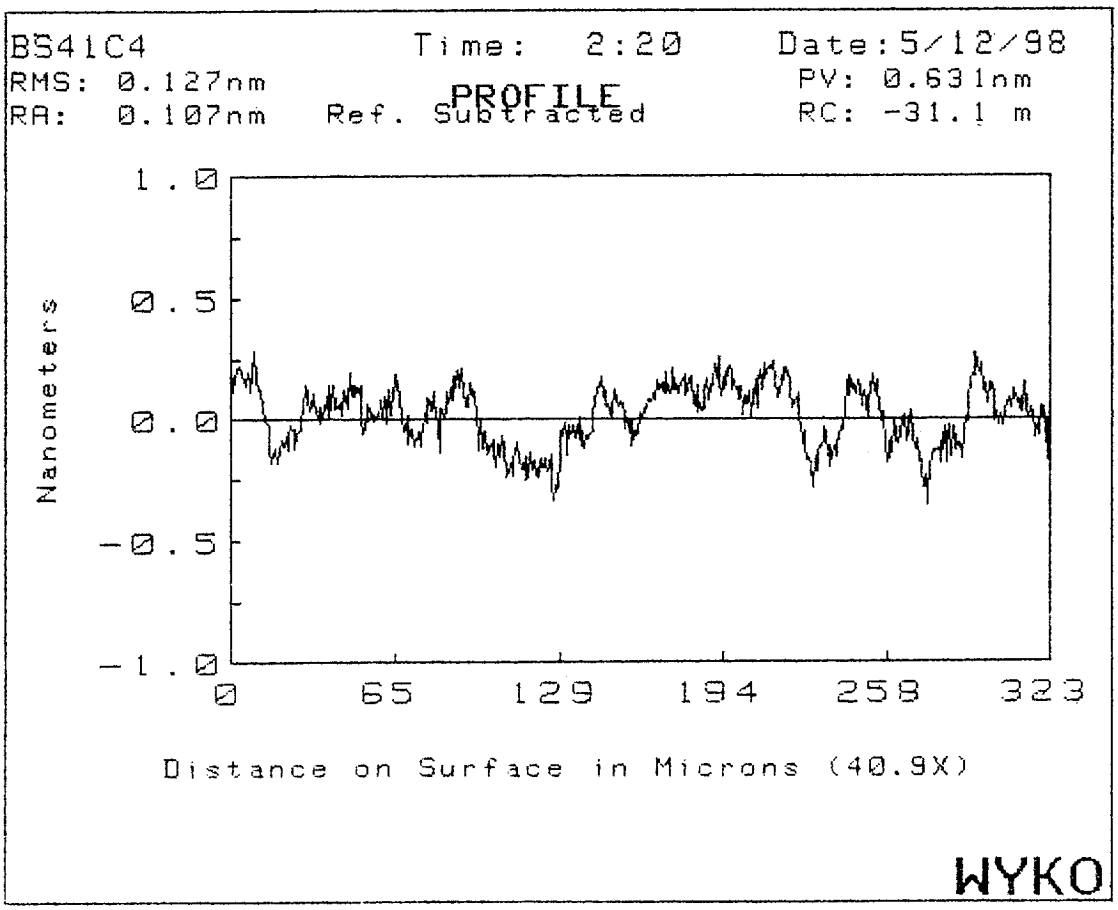

T4BS41A.asc



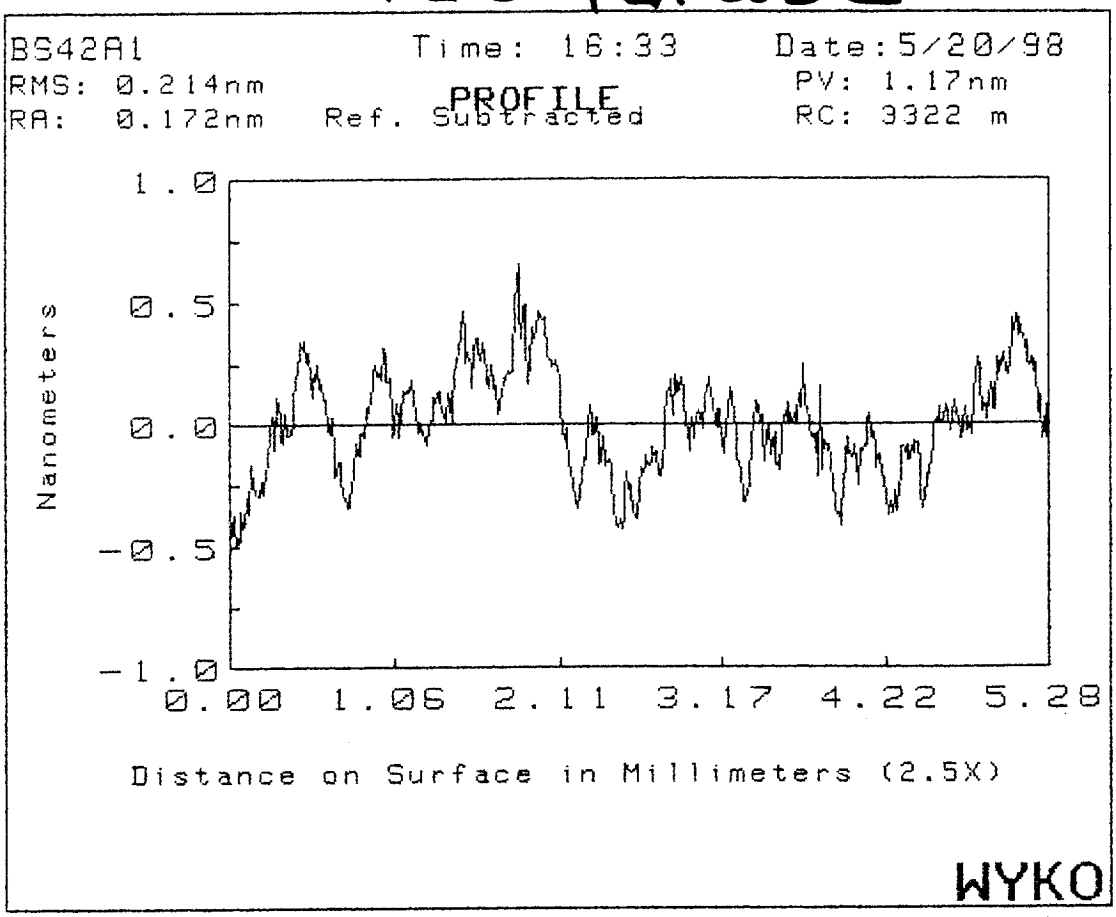
# T4BS41B.asc




# T4BS41C.asc

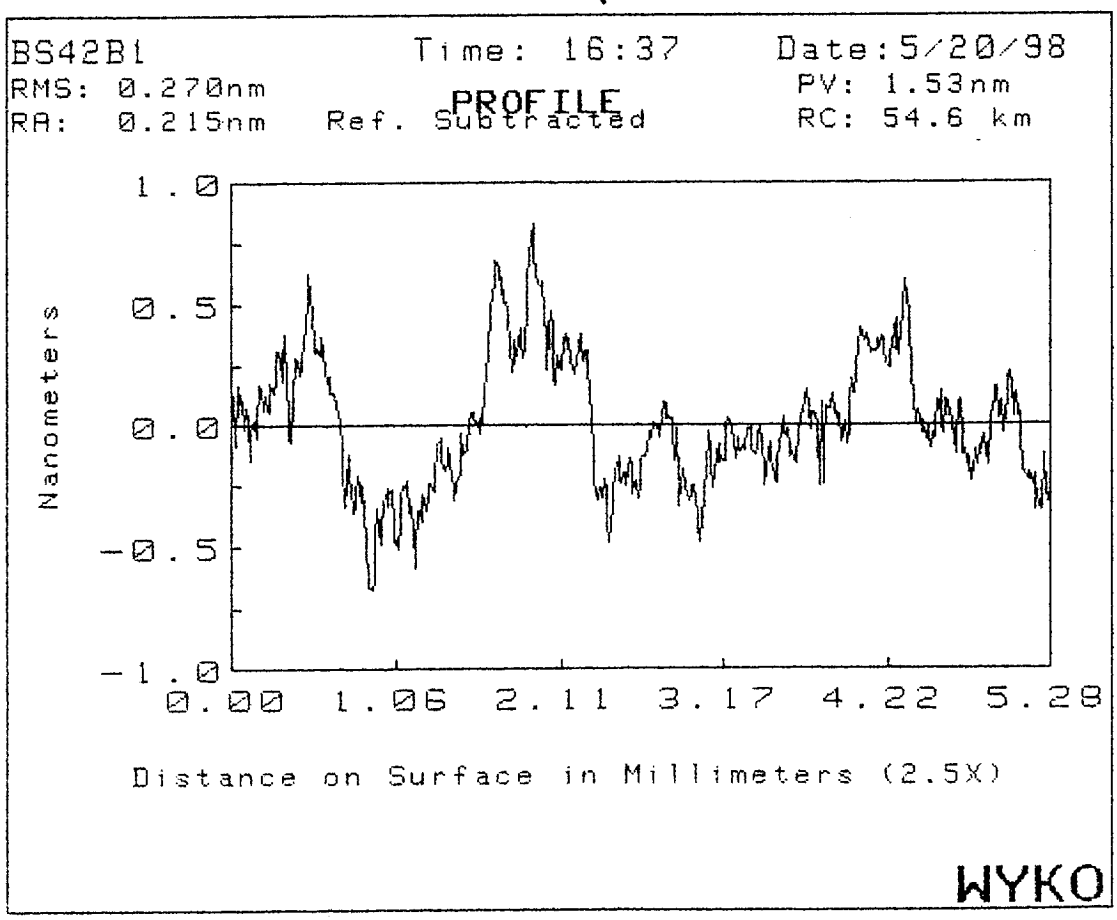


T2BS42A.asc

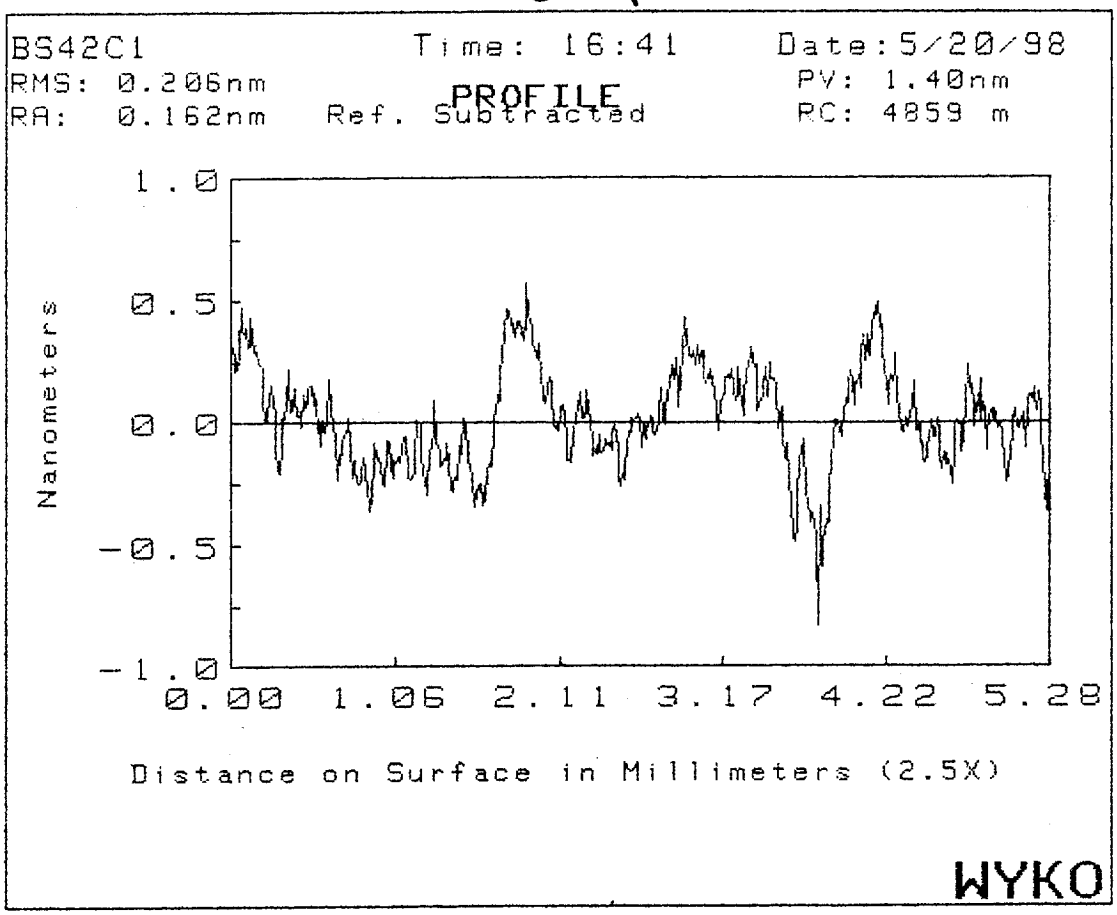



Att. 4

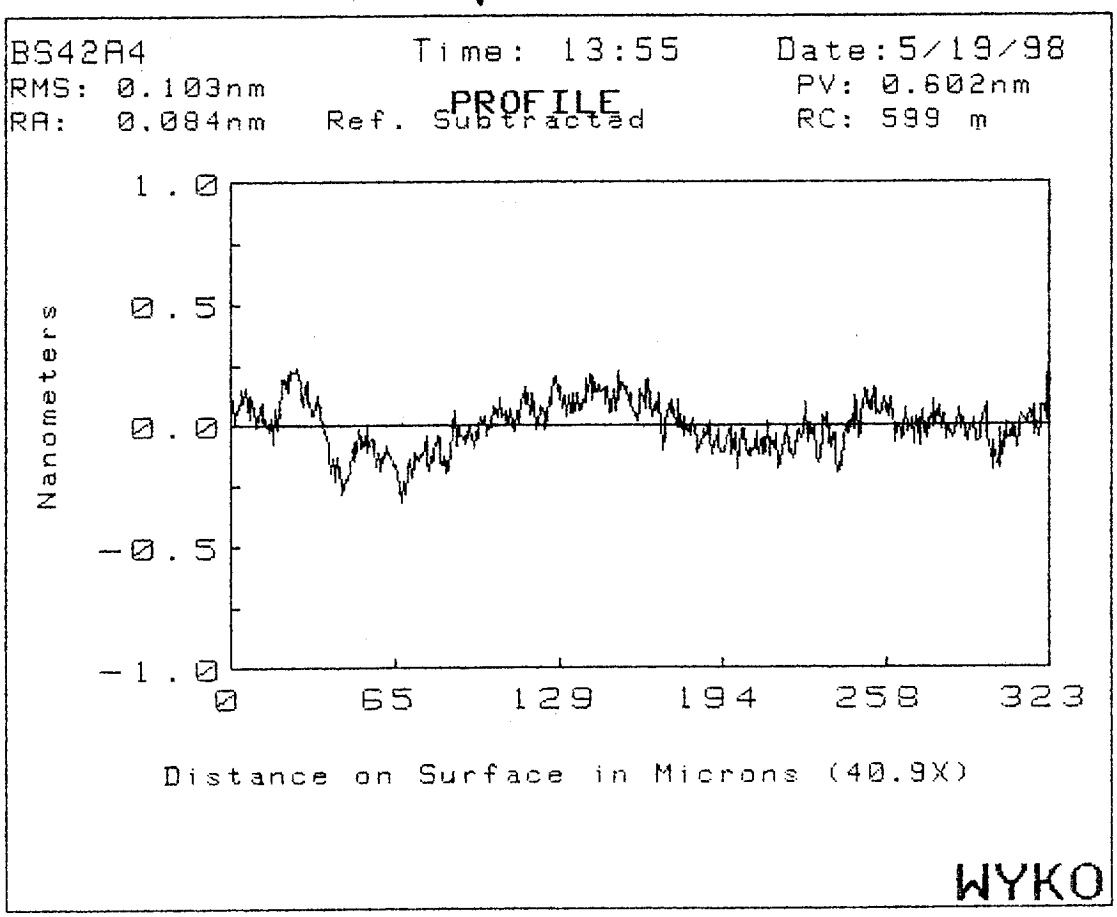
T2BS42B.asc



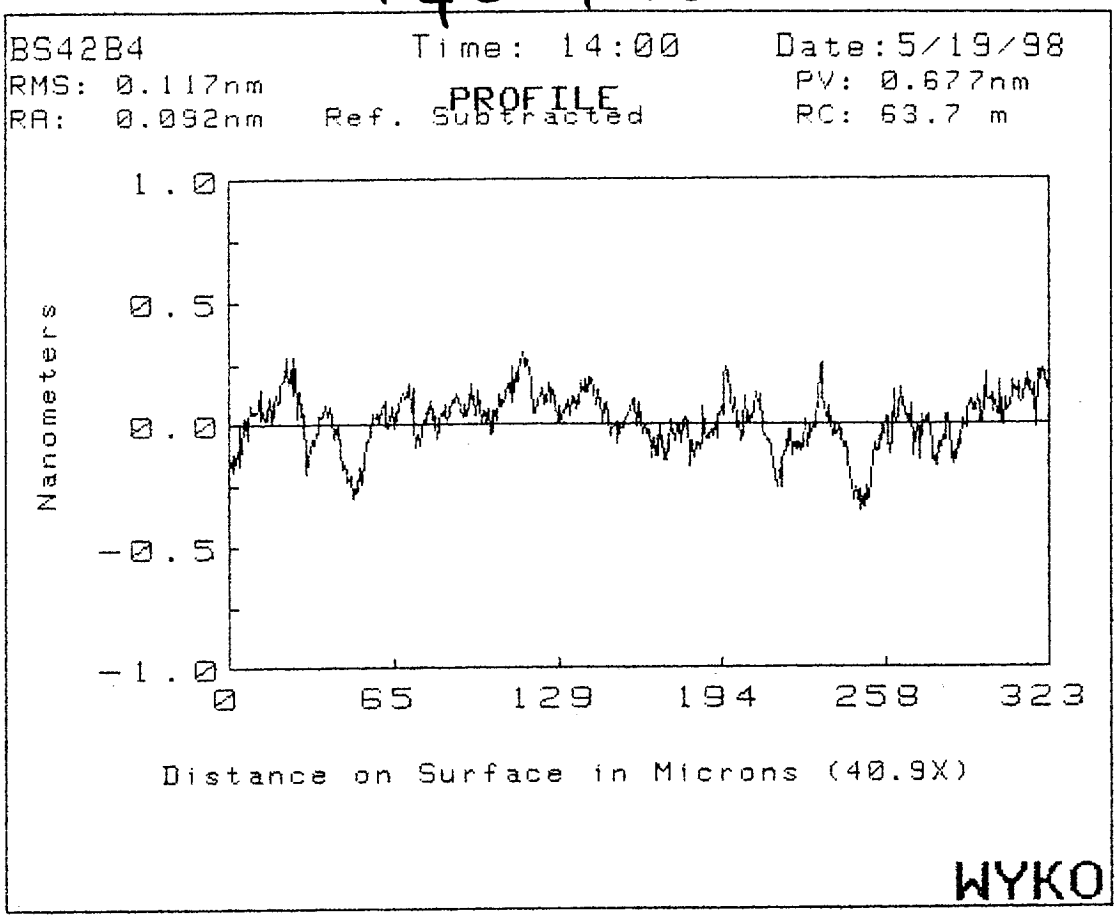
T2BS42C.asc



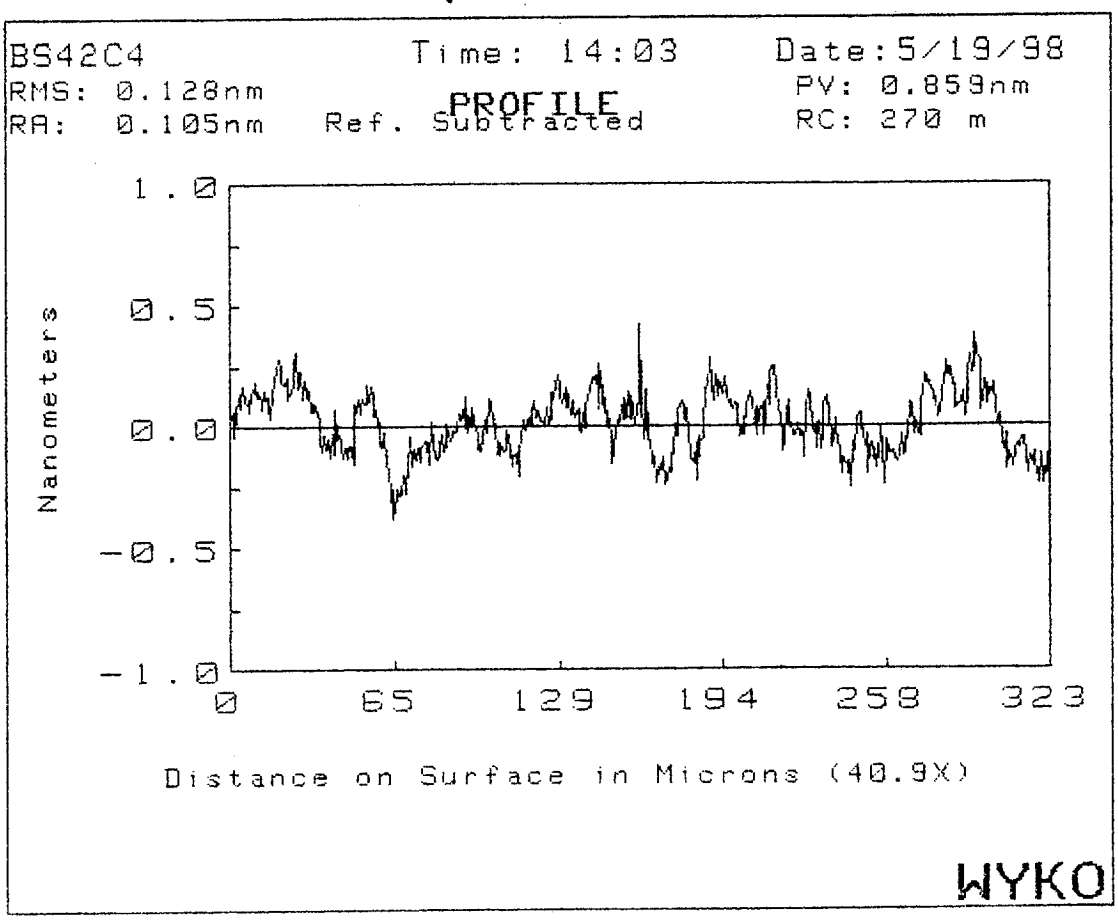

T4BS42A.asc



T4BS42B.asc




T4BS42C.asc




MIRROR

## BS04-B

08-13-98 Received coated beamsplitter from REO

08-17-98 Returned to CSIRO for repolish due to faulty coating by REO.

# 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 : 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. : OPTO5831-22 Run No.: OX779 - Beam Splitter OX783 - AR
- Qty. Shipped/Lot No. : 1 ea BS03 1 ea 1" dia. witness
  1 ea BS04

☒ Test data (included)

**Comment:**

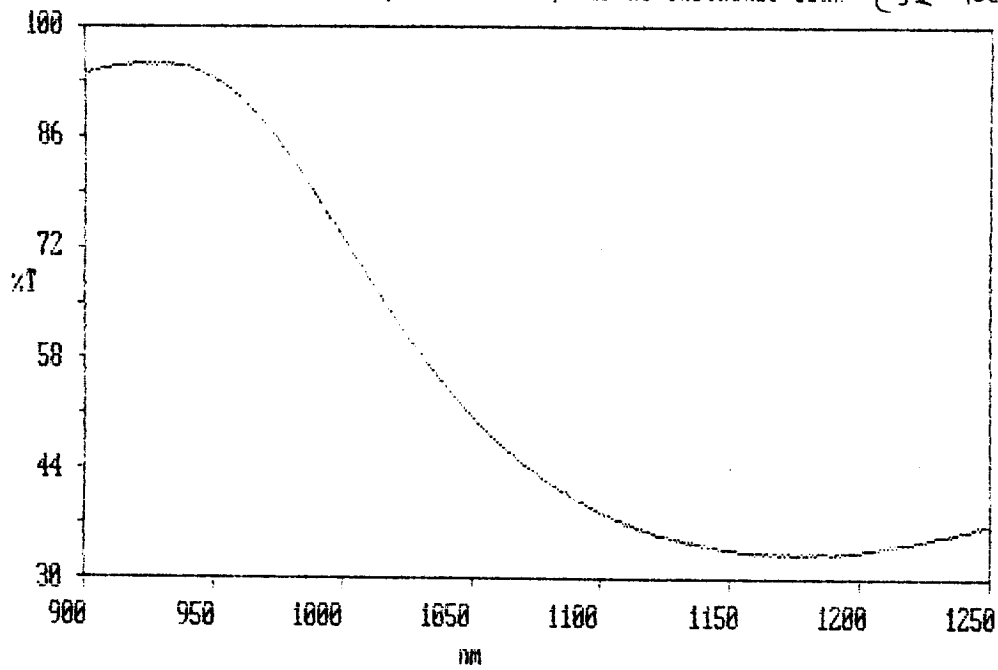
Certified by: _____, 7/31/98
Quality Assurance

Verified by: _____, 31 July 98
Engr/Tech

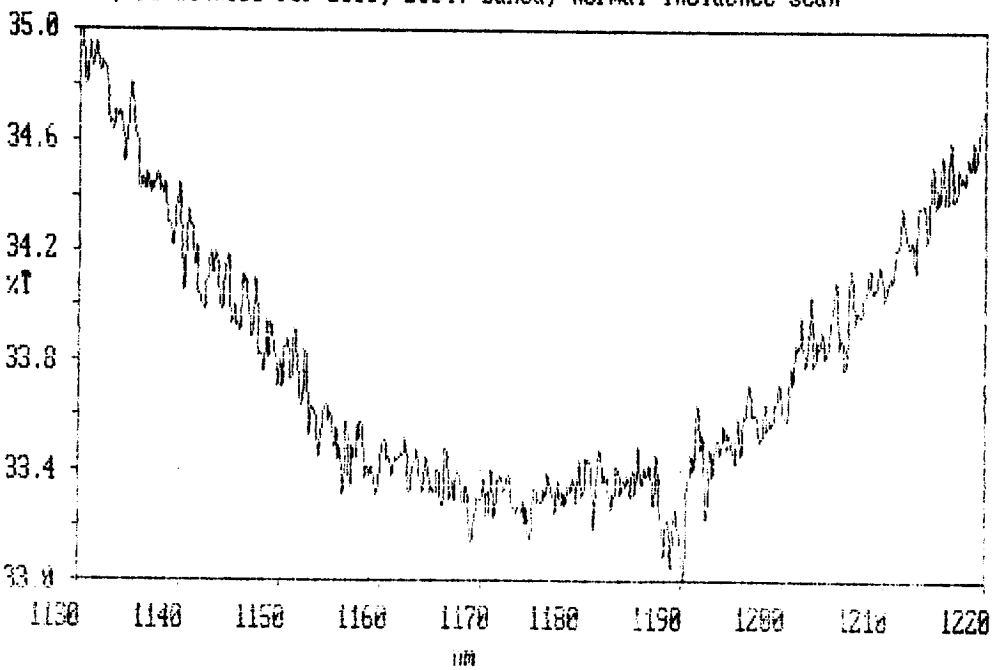
*NOTE*
*Certificate must accompany the package to be shipped or attached to the outside of the same box to which the "Packing Slip" envelope is attached.*

BSØ4-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)

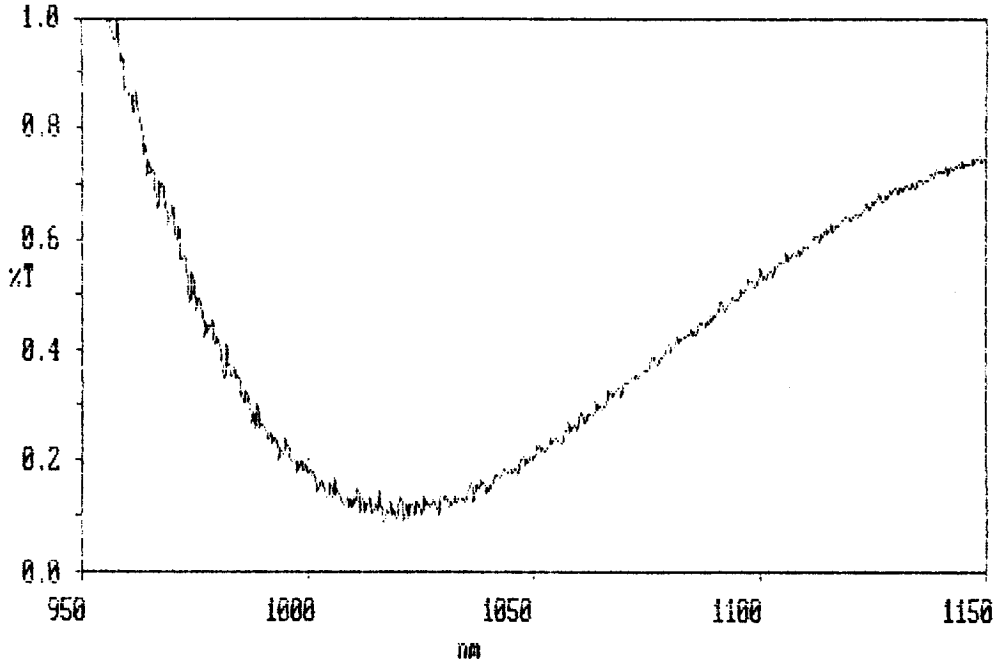



X: user004: 1250.0 - 900.0 nm; pts 3501; int 0.10; ord 33.000 - 95.705 %T
Inf: #0X779, FS witness for BS03, BS04. Baked, normal incidence scan



BS04-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