ETM01

LIGO-T990140-00-D

BLANK

T970014 FE Ø6
ETM Ø1

LIGO DETECTOR OPTICS
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.

LIGO Contract No.: PP207573
Core optic Material: (BS/FM/ITM/ETM/RM)
LIGO Drawing No.: D960794-A-D
Optical Glass Spec. MIL-G-174-B

Glass Mfg./Order No: Corning /QD10624801
Glass Mfg. Part No.: ~~246226~~F FEØ6 F855306 (SE)
Manufacturer's Boule No.: 246226F (SE)
Date Received at Caltech: 1-08-~~98~~ 97 (SE)

☑ Verify glass manufacturer's Certification against LIGO Component Specification No.. E960097-A-D

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

☑ Attach the glass manufacturer's optical phase maps supplied by vendor per above Component Specifications.

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

☑ Visually inspect the blanks for damage, for chips on surfaces and edges, or for other defects. If applicable, describe damage/defects on attached sheet and notify Cognizant Engineer. Date Notified: NA

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

- ☑ Inspection of material diameter. Diameter 10.105" 256.77 mm
- ☑ Inspection of material thickness. Thickness 4.2910" 109.01 mm
- ☐ ~~Inspection of chamfer.~~ → NA

☑ Verify that the Registration Mark is present as required by LIGO Component Specification.

☑ Verify receipt of 25mm X 25mm cylinder Witness Sample(s) required by the LIGO Component Specification and visually inspect for damage. If applicable, describe damage on attached sheet and notify the Cognizant Engineer. Date Notified: NA

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

Inspect By: _____ Date Inspected: 1-10-97

Reviewed and/or accepted by:

Cognizant Engineer: _____ Date: 2-25-97

LIGO QA Officer or Designee: _____ Date: _____

FM300

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.) _____

SKETCHES:

DISPOSITIONS: _____

I-36-R

CORNING INCORPORATED
CORNING
CORNING, NEW YORK

SHIPPING ORDER
PACKING LIST

T. ORD. & DATE [P950[illegible] 05 20/96]

CNG ORD NO. [CD1060243]

DATE SHIPPED	INVOICE NUMBER

SOLD TO
CALIFORNIA INSTITUTE OF TECHNO 13.17
ACCOUNTS PAYABLE MC 201-6 04 056 04
1200 E CALIF BLVD
PASADENA, CA 91125

SAME AS "SOLD TO" UNLESS OTHERWISE SPECIFIED

SHIP TO
CALIFORNIA INSTITUTE OF TECHNO 13717
ATTN: MR. LOWELL JONES
391 S HOLLISTON 04 056 02
PASADENA, CA 91106

DATE SHIPPED
ROUTING 5263
BEST WAY UPS Ro
CAR INITIAL AND NUMBER

THIS SHIPMENT PARTIAL	THIS SHIPMENT COMPLETE	PREPAID
		X

SALES CODE [110 050]
DISCOUNT FACTOR [ ]
DESIRED SHIP DATE [12/20/96]
SHIPPED O.B. [CANTON, NY DF1 FOB ORIG PPD FRT INVOICED]
DATE ENTERED [08/28/96]
WE EXPECT TO SHIP [12/20/96 11/20/96]
DATE ISSUED [12/18/96]
DATE TO SHIP [12/20]

	WHSE LOC.	PRODUCT CODE	DESCRIPTION	QUANTITY UNITS	QUANTITY CASES
001	855306	7980 0000	DISC, F S,O A, 10.079"D X 4.252"T,BLANK TOLERANCES: + 040"/-.000" BOTH DIMS FOLLOWS MIRROR END TEST PASSES CLEAR APERATURE = 3.952" PRICE INCLUDES 12 WITNESS SAMPLES SAMPLE DIMENSIONS: .984" x .984" CYLINDRICAL WITNESS SAMPLES FROM NEARBY PORTION OF BOULE * BLANKS & CORRESPONDING WITNESS SAMPLES SHALL BE SERIALIZED AS FEXX, WHERE XX INCREMENTS STARTING AT 01 ** SPEC #: LIGO-E950097-A-D DWG#: LIGO-D950794	3 A BW	PC
003	855308	7980 0000	DISC, F S,OA,WITNESS SAMPLE, .984" X .984" CYLINDRICAL YOUR PRODUCT IDENT -03 WITNESS SAMPLES WITNESS SAMPLES FOR ITEMS 1 PRICE IS INCLUDED IN ITEM 001	3 A BW	PC

12-19-96
Rec'd 3 cartons in good Condition.
Steven Pierson

FE 96

UTING

CORNING
334 County Route 16
Canton, New York 13617-9703

Canton Plant . . .

...WHERE QUALITY MIRRORS PRIDE

CERTIFICATE OF COMPLIANCE

Customer: California Institute of Technology

Item: 001

Customer Order No.: PP207573

Glass: 7980 Grade 0A

Corning Order No.: QD106248

Quantity Shipped: 3

Code No.: 855306

Date Shipped: 1/8/97

Registration Mark for & Serial # per LIGO
Drawing # D960794-A-D
Biregringence ≤ 1 nm/cm central 80 mm
≤ 5 nm/cm central 200 mm
Striae per MIL-G-174 Section 4.46 method 1 or 2.

This is to certify that the above material shipped against your order is in conformance with all applicable requirements, specifications, and drawings.

FE Ø4
FE Ø5
FE Ø6

Signed: Brian C. Bush

Brian C. Bush

Title: Quality Assurance Section Leader

Date: 1/8/97

DEVIATION APPROVAL FORM

Customer Name: California Inst. Technology

Customer P.O. Number: PP 207573

Corning Order Number: QD106 94801

Corning Part Number: F 855306

Drawing Number: E960097-A-D - LIGO - D960794

Boule Number:

Quantity Affected: 11 (FE01 Thru FE 11)

Deviation Description: SBT PICS to be used in lieu of individual pics of each piece
(attach backup information as deemed necessary

Cari Lynn Billingsley
Customer Contact (print)

2-24-97

Authorizing Signature

12/12/96
Date

Send copy with shipment? (Y) N
(circle Yes or No)

Billing Status

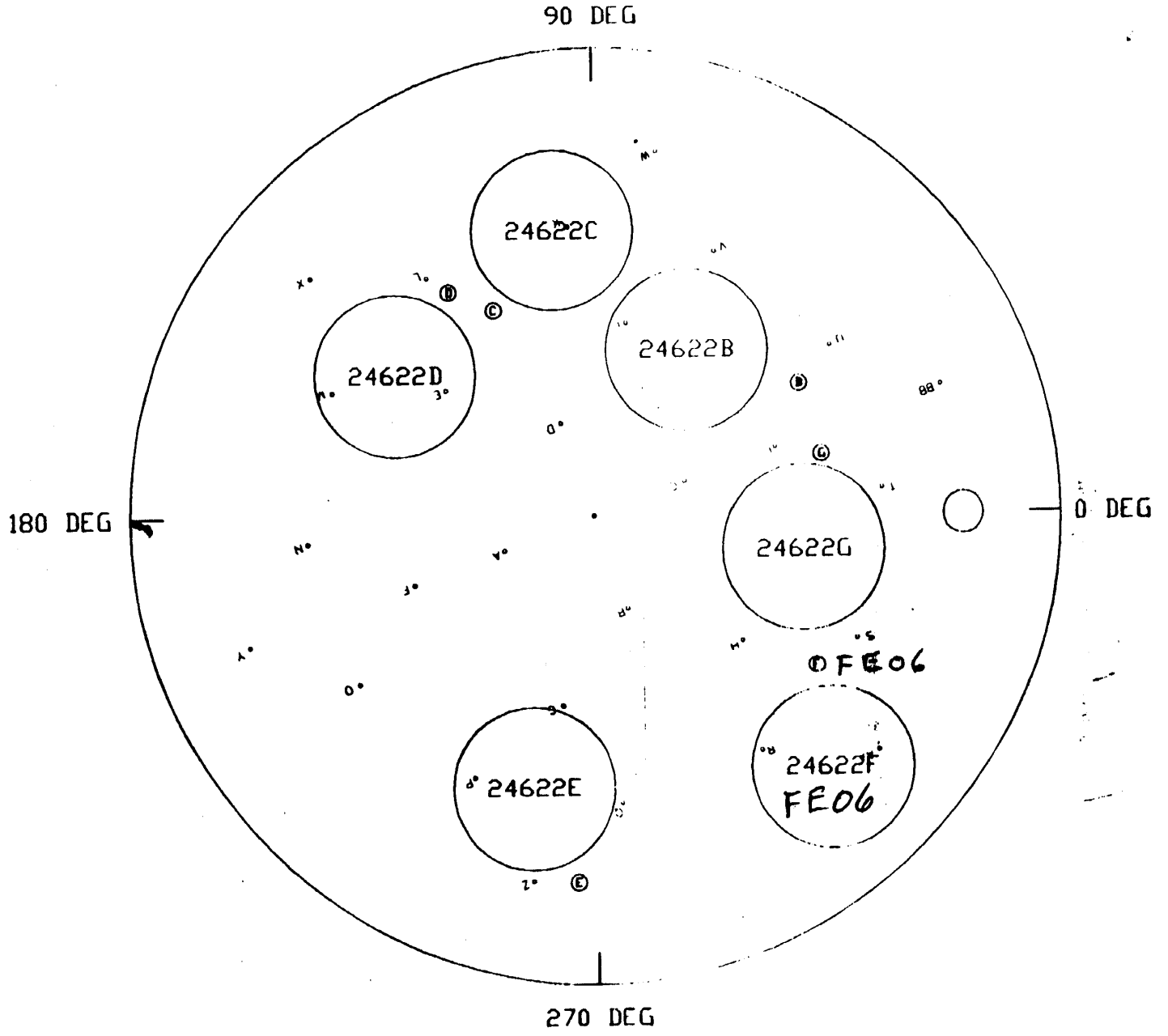
- ☐ Bill Now
- ☐ Bill in 30 Days
- ☐ Other

Deviation Number: FE Ø6
(sequential number) - (year)

cc: Shipping Clerk
Customer Service

Q704 rev. A

24622F-SNFE06



DATA SHEET - CAL TECH LIGO MIRROR BLANKS

Cal Tech Purchase Order Number: PP207573

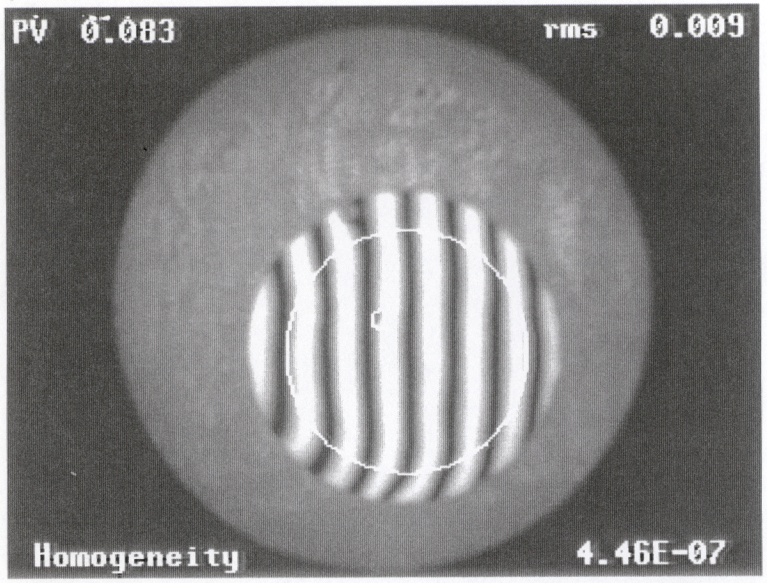
Cal Tech Drawing Number: LIGO-D960794

Attribute	Specification #	Requirement	Actual	Stamp	
Diameter	Per LIGO - D960097-A-D	10.079", -0.0"/+0.4"	10.105 / 10.105		QA
Thickness	Per LIGO - D960097-A-D	4.252",- 0.0" / + 0.4"	4.2905 / 4.291 / 4.291 / 4.2905		QA
Registration Mark	Per LIGO - D960794	Top center of optic	See Attached Cert.		M
Serial & Boule #	Per LIGO -D960794	Boule and Serial No.	24622F-FE06		M
Material	Fused Silica 7980		See Attached Cert.		M
Witness Sample Map			See Attached Map		M
Defects		< 0.5 mm	See Attached Map		QA
Inclusions		< 0.1 mm; < 0.03 $mm^2/100cm^2$; < 0.06 mm disregard	See Attached Map		QA
Homogeneity - central		Peak To Valley < 1.0 x 10E-6	$5.03 \times 10E^{-8}$		M
Homogeneity - outside		Peak To Valley < 2.5 x10E-6	$4.46 \times 10E^{-7}$		M
Interferograms		To be provided	Attached		M
Birefringence	MIL G-174 Section 4.4.5	< 1nm/cm (central 3.150") < 5 nm/cm (central 7.874")	See Attached Cert.		QA
Striae	MIL G-174 Section 4.4.6, Method 1 or 2	Grade A	Inspection Report		M
Absorption		< 20 ppm / cm @ λ = 1.06 μm	See attached Cert.		M

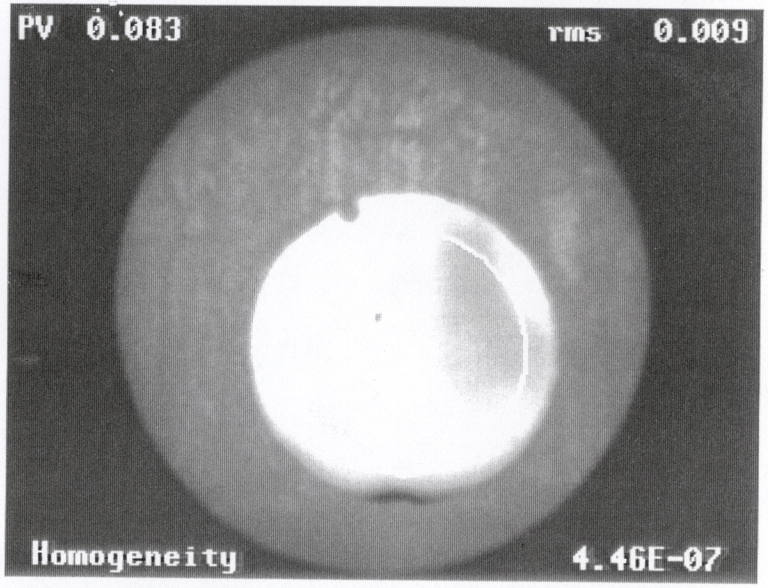
Comments:

Inspected by: Gail Andrews Date: 1-8-97

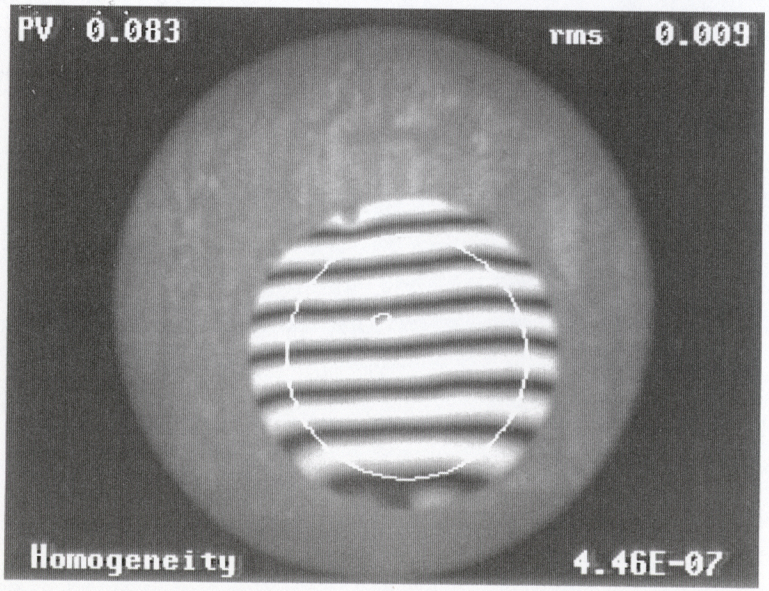
CORNING INCORPORATED



24622F SN-FE06



24622F FE06



24622F FE06

zygo

Homogeneity

Lg Aperture

PV 0.083 wave

rms 0.009 wave

Power 0.000 wave

Homogeneity 4.46E-07

Points 8171

AstMag (Z) 0.024 wave

zygo Spike

Remove Spikes: Off | (xRMS): 3.00

Data Fill: Off | Data Fill Max: 25

Removed:

PST TLT PWR

PST | TLT | PWR | AST | CMA | SA3

Zern Terms: 36

Zernike Coefficients from 8170 data points

Order: 10th Terms: 36 rms: 0.002

```
 0.000  0.000  0.001 -0.001
 0.011  0.004 -0.004 -0.001 -0.009
-0.001 -0.012  0.007 -0.001  0.001  0.008 -0.001
-0.006 -0.004  0.000 -0.004  0.000 -0.003  0.000  0.001 -0.001
 0.006  0.003  0.001  0.001 -0.001  0.000  0.001  0.001  0.001
```

Measure | Mask Data | Save Data | DBSAVE

Analyze | Calibrate | Load Data

zygo File Data

Subtract Sys Err: On

Sys Err File: r121396.8a2

Part Thickness: 4.62 in

Boule #: 24622

Suffix: F

Comment: CAL TECH SN-FE06

Data File: 24622F1.ct

Camera Res: 1.9600 mm

Time: Sat Jan 04 06:08:09 1997

Min Mod (%): 1

Phase Res: High

Scale: 0.500

AGC: Off

Light Level: 110

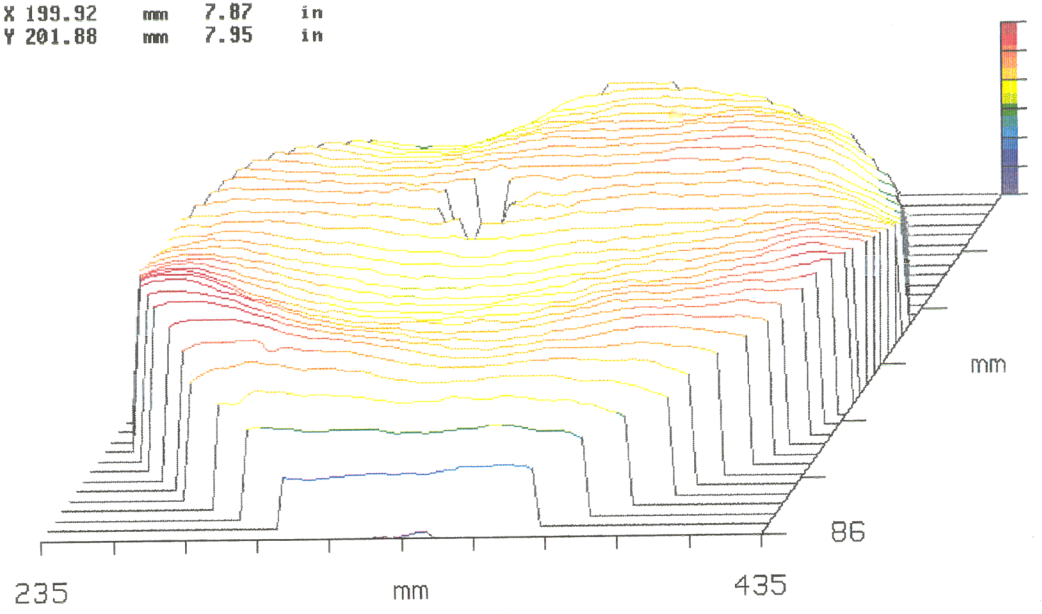
Phase Avgs: 6

Intens Avgs: 6

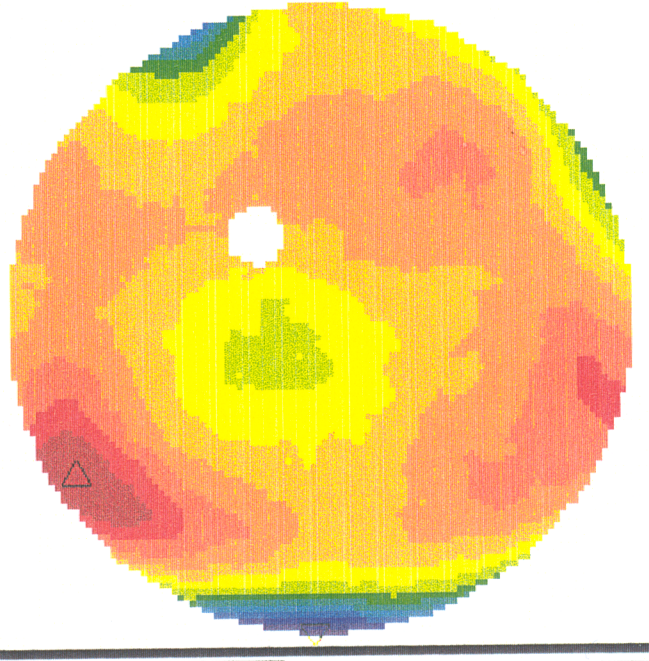
Corning Inc. Canton Plant Metrology Dept. 334 Co. Rt. 16, Canton, NY 13617 (315) 379-3283

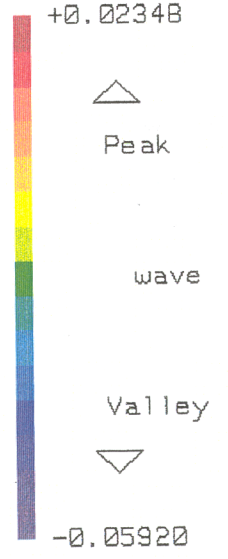
Size X 199.92 mm 7.87 in

Size Y 201.88 mm 7.95 in



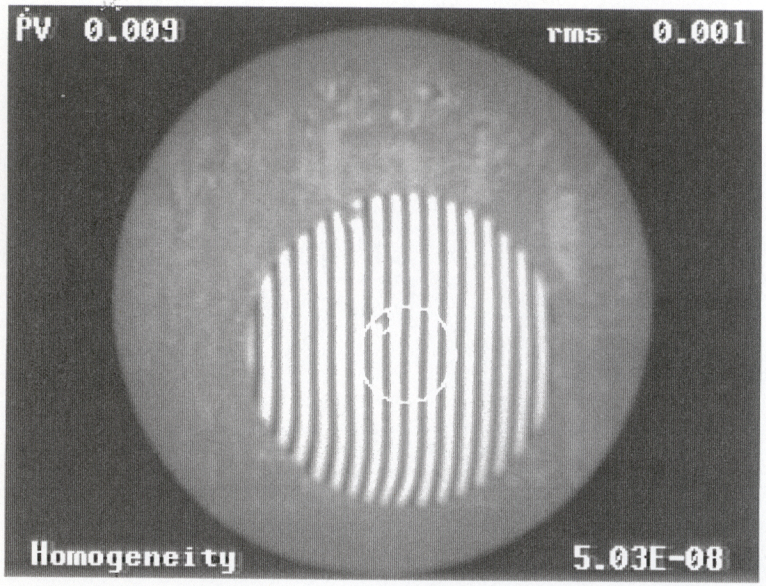
Save Subapt



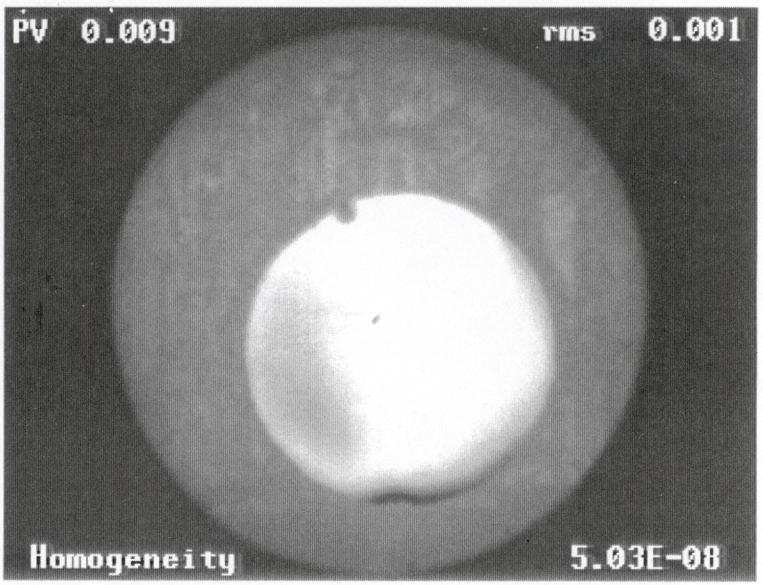


SlopeMag | TiltXY | Filter | AutoSeq | Manipulate | Metroscript

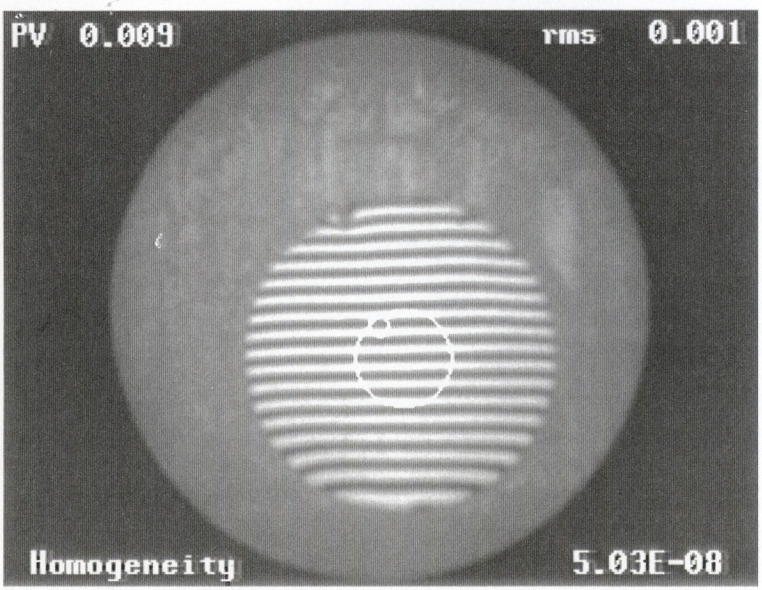
Profile | VideoMon | SlopeY | SPC | Meas Controls | FileCopy | Report | ZernGen



24622F SN-FE06



24622F FE06



24622F FE06

zygo — Homogeneity

Lg Aperture

PV 0.009 wave

rms 0.001 wave

Power 0.000 wave

Homogeneity 5.03E-08

Points 1275

AstMag (Z) 0.005 wave

zygo — Spike

Remove Spikes: Off | (xRMS): 3.00

Data Fill: Off | Data Fill Max: 25

Removed:

PST TLT PWR

PST | TLT | PWR | AST | CMA | SA3

Zern Terms: 36

Zernike Coefficients from 1274 data points

Order: 10th **Terms:** 36 **rms:** 0.001

```
  0.000  0.000  0.000  0.000
 -0.002 -0.001 -0.001 -0.002 -0.001
  0.000  0.000  0.000  0.000  0.000  0.000  0.000
 -0.001  0.000  0.000  0.000  0.000  0.000  0.000 -0.001  0.000
 -0.001 -0.001  0.001  0.000  0.000  0.000  0.000  0.000  0.000
```

Measure | Mask Data | Save Data | DBSAVE

Analyze | Calibrate | Load Data

Subtract Sys Err: On

Sys Err File: r121396.8a2

Part Thickness: 4.617 in

Boule #: 24622

Suffix: F

Comment:

CAL TECH SN-FE06

Data File: 24622F2.ct

Camera Res: 1.9600 mm

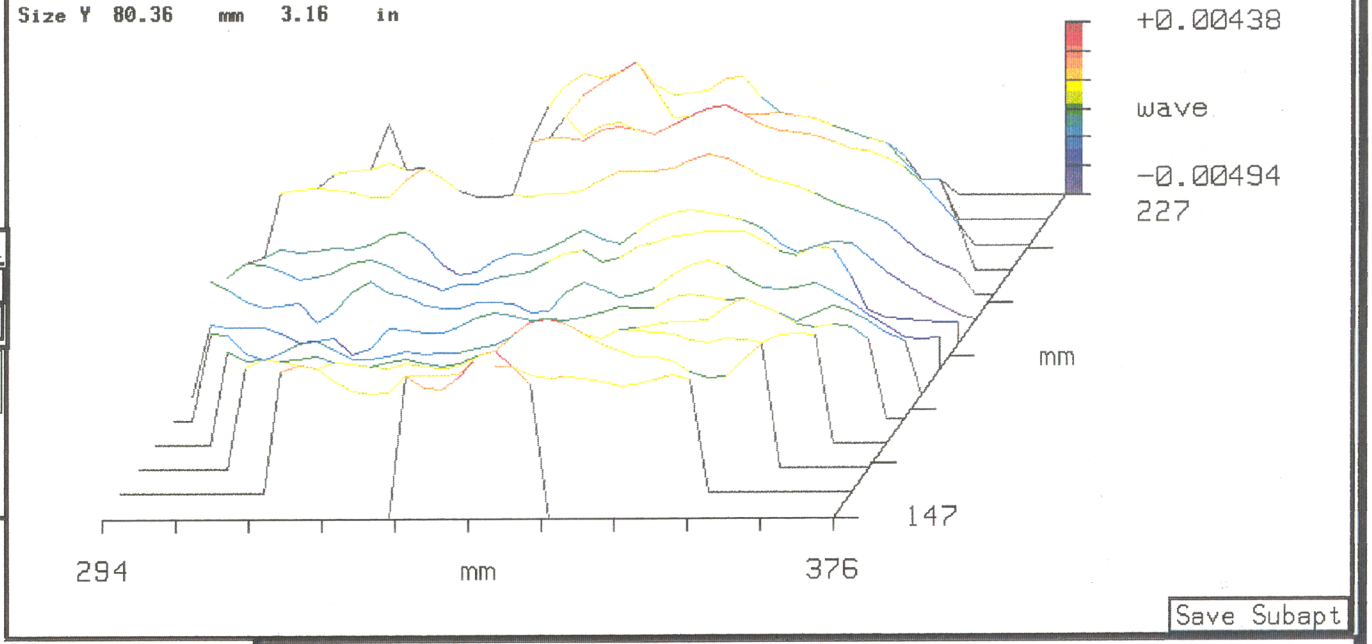
Reset

Time: Sat Jan 04 06:08:09 1997

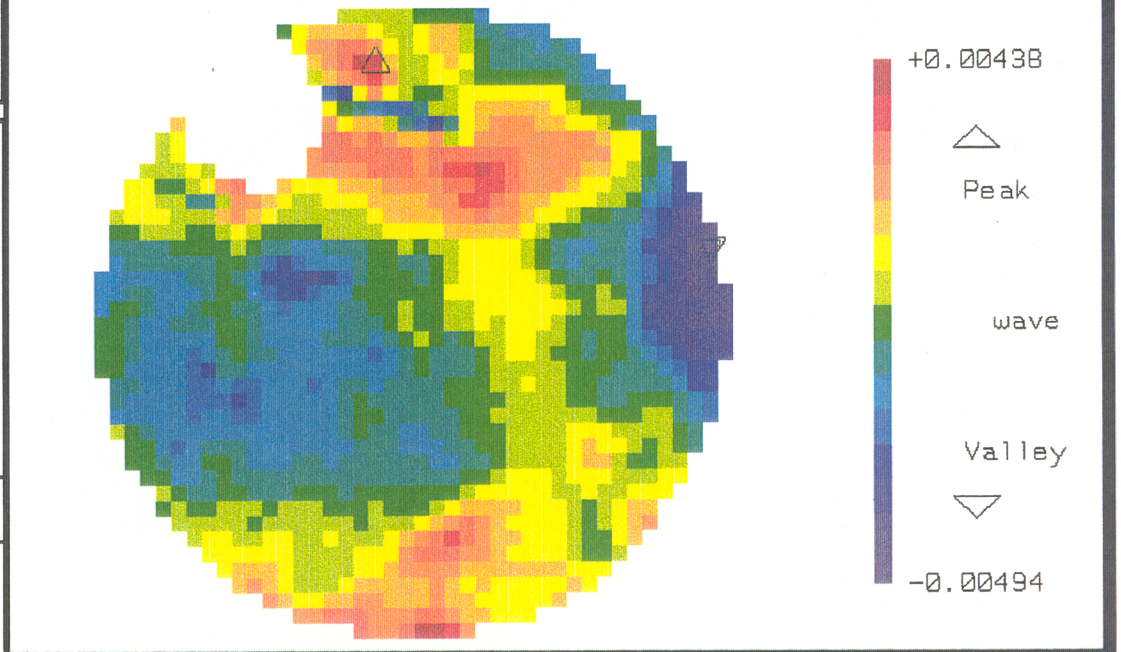
Corning Inc. Canton Plant Metrology Dept. 334 Co. Rt. 16, Canton, NY 13617 (315) 379-3283

Size X 82.32 mm 3.24 in

Size Y 80.36 mm 3.16 in



Save Subapt



SlopeMag | TiltXY | Filter | AutoSeq | Manipulate | Metroscript | FileData

Profile | VideoMon | SlopeY | SPC | Meas Controls | FileCopy | Report | ZernGen

pertains to serial numbers
FE01 — FE09 - BB

Canton Plant
334 County Rt 16
Canton, New York 13617

Corning Incorporated

February 17, 1997

California Institute of Technology
LIGO Project
51-33 East Bridge Laboratory
Pasadena, CA 91125

Dear Ms. GariLynn Billingsley:

This letter is in response to concerns indicated in your reference to: Review of Data Packages for first 9 Pieces.

1) Diameter and thickness to reference drawing # D960794-A-D.
   QA Inspectors are aware of this requirement. Change will be made on shipment of next parts.

2) Registration Mark and Serial number should reference specification E960097-A-D.
   QA Inspectors are aware of this requirement. Change will be made on shipment of next parts.

3) Blanks FE04, FE05, FE06 & FE08 had no arrow to point to side 1, but commenced at a surface where there was a reasonable amount of writing.
   Your assumption is correct. The surface with the reasonable amount of writing is side 1.

4) Specification for arrow and registration mark will be followed on shipment of next parts.

5) Any exceptions to specifications will be noted on data pack in future. QA Inspectors are aware of this requirement.

6) Birefringence readings are indicated on the defect and inclusion maps. This map serves both purposes.

7) Absorption reading not necessary for part # E970097-A-D. This column on Data Package will be marked N/A for balance of these parts.

8) The Certification of Compliance applies to all pieces shipped with order. This will be noted on the C of C in the future.

9) Serial Numbers will be included on the shipper.

10) Specification revision number referenced on Data Pack.
    QA Inspectors aware of requirement. Will be done on next shipment of parts.

cc:
Petrac
Camp
Elieson
Tyler

11) Data Disk not sent with pieces of glass.
Missing information will be forwarded. QA Inspectors will double check contents of Data Packs.

12) Deviation Approval Form sent with initial material shipment.
Approval of first 3 pieces analyzed via Standard Boule Testing. All other parts analyzed separately.

Other:
Standard Boule Testing could be acceptable to the LIGO project given confirmation by Corning Metrology that the interferometer used for SBT is the same used to test individual pieces, and that there is no change in magnification.

This response from Mr. Andy Fanning, Corning, Canton, Metrology Dept.
"The standard process Corning-Canton uses in metrology is compliant with the CIT/LIGO fax to Randy VanBrocklin ,dated January 31st, 1997. The interferometer and magnification will be the same regardless if the part is shot at it's final dimension or in boule form".

If additional clarification is required on this subject, please let me know.

Hopefully this document addresses the current issues between CalTech -LIGO project and Corning-Canton. If there are any additional issues that need to be addressed by Corning, please do not hesitate to contact me.

Thank you for your patience in this matter.

Sincerely,

Randy VanBrocklin
Applications Engineer

Tel: 315-379-3381
Fax: 315-379-3317

CALIFORNIA INSTITUTE OF TECHNOLOGY

LIGO Project, 51-33 East Bridge Laboratory, Pasadena, California 91125
818-395-2129, Fax 818-304-9834

Date: January 31, 1997
Refer to: LIGO-C970148-00-D

Corning Incorporated
Canton Plant
334 Country Route 16
Canton, New York 13617
Attention: Randy VanBrocklin, Brian Bush

Subject: Review of Data Packages for first 9 pieces

Some clarification of preferences and some discrepancies came to light during examination of the data packages for the first 9 blanks delivered to LIGO. While none of these compromise the integrity of the blanks, they can make for a confusing or misleading data package. Please let us know how you expect to address these issues for subsequent glass deliveries.

1. Data sheet; Diameter and Thickness should reference the drawing D960794-A-D
2. Data sheet; Registration Mark and Serial number should reference the Specification E960097-A-D
3. Blanks FE04, FE05, FE06 and FE08 had a registration mark which was between 12-15 mm in length and had no arrow to point to side 1, but commenced at the surface on which there was a reasonable amount of writing. We have presumed this to be side 1 but would appreciate a confirmation that this is indeed the case
4. Also, on these blanks the serial number is written immediately adjacent to the registration mark and is parallel to the (presumed) side 1, rather than as shown in the drawing. This is not a problem for us as the serial number is clear, but strictly speaking it is not in compliance with the specification.
5. We have a data package that arrived with no witness sample map, yet this item was stamped off on the data sheet, with no note of exception. An exception had been granted for this part, that exception was included in the data package. Please note the presence of an exception on the data sheet.
6. All data packages have arrived without defect or inclusion maps yet the box next to "see attached map" was stamped. How should LIGO interpret the stamp column? Please provide defect and inclusion maps.
7. Data packages arrived with the "Actual" column for Absorption reading "see attached cert", yet there was no attached certification, nor was one required for this part. There was a stamp.
8. The Certification of Compliance does not reference serial number(s) are we to assume that it applies to all pieces in the shipment?
9. Would you please include serial numbers on the shipper?

10. Would you please reference the Specification Revision number on the data sheet?
11. A data disk is required with the package, yet one piece has arrived without it. Should there be a checkoff sheet for each piece of glass stating the contents of the data package?
12. A Deviation Approval form accompanied the shipment of FE01 approving standard boule testing for 11 pieces. The form does not indicate which pieces are affected. LIGO has no record of approving this deviation. Please confirm all future Deviation Approvals in writing.

NOTE: Standard Boule Testing could be acceptable to the LIGO project given confirmation by Corning Metrology of the following information. The Interferometer used for SBT is the same interferometer which is used for single piece testing and there is no change in interferometer magnification between SBT and single piece homogeneity measurements. Deviation approval for SBT will be considered by LIGO following this clarification.

Sincerely,

GariLynn Billingsley
Technical Representative

SUBSTRATE

GO **GENERAL OPTICS, INC.** **PRECISION OPTICAL COMPONENTS**

554 FLINN AVENUE MOORPARK, CALIFORNIA 93021 (805) 529-3324 FAX (805) 529-4298

CERTIFICATE OF COMPLIANCE

Date: 07-07-97

To: Cal Tech

Purchase Order Number: PC203459

Part Number & Revision: D960791-A-D (w/Spec. #E950104-A-D)

Part Description: Ligo End Test Mass Substrate

Serial Numbers: SP ETM 01A

We certify that the above part was manufactured in compliance with all applicable requirements and specifications of the above purchase order and drawings except as noted below.

"Scratches" and "Point Defects" for the entire side 1 and side 2 surfaces were inspected using an high intensity white light source delivered perpendicular the surface. This was substituted for the method prescribed in specification E950104-A-D.

GENERAL OPTICS, INC.

By: 

GO **GENERAL OPTICS, INC.** **PRECISION OPTICAL COMPONENTS**

554 FLINN AVENUE MOORPARK, CALIFORNIA 93021 (805) 529-3324 FAX (805) 529-4298

CERTIFICATE OF COMPLIANCE

Date: 07-07-97

To: Cal Tech

Purchase Order Number: PC203459

Part Number & Revision: D960791-A-D (w/Spec. #E950104-A-D)

Part Description: Ligo End Test Mass Substrate

Serial Numbers: SP ETM 02A

We certify that the above part was manufactured in compliance with all applicable requirements and specifications of the above purchase order and drawings except as noted below.

"Scratches" and "Point Defects" for the entire side 1 and side 2 surfaces were inspected using an high intensity white light source delivered perpendicular the surface. This was substituted for the method prescribed in specification E950104-A-D.

GENERAL OPTICS, INC.

By: _____

GENERAL OPTICS, INC. **PRECISION OPTICAL COMPONENTS**

554 FLINN AVENUE MOORPARK, CALIFORNIA 93021 (805) 529-3324 FAX (805) 529-4298

CERTIFICATE OF COMPLIANCE

Date: 07-07-97

To: Cal Tech

Purchase Order Number: PC203459

Part Number & Revision: D960791-A-D (w/Spec. #E950104-A-D)

Part Description: Ligo End Test Mass Substrate

Serial Numbers: SP ETM 03A

We certify that the above part was manufactured in compliance with all applicable requirements and specifications of the above purchase order and drawings except as noted below.

"Scratches" and "Point Defects" for the entire side 1 and side 2 surfaces were inspected using an high intensity white light source delivered perpendicular the surface. This was substituted for the method prescribed in specification E950104-A-D.

GENERAL OPTICS, INC.

By: _____

GENERAL OPTICS, INC. **PRECISION OPTICAL COMPONENTS**

554 FLINN AVENUE MOORPARK, CALIFORNIA 93021 (805) 529-3324 FAX (805) 529-4298

CERTIFICATE OF COMPLIANCE

Date: 07-07-97

To: Cal Tech

Purchase Order Number: PC203459

Part Number & Revision: D960791-A-D (w/Spec. #E950104-A-D)

Part Description: Ligo End Test Mass Substrate

Serial Numbers: SP ETM 04A

We certify that the above part was manufactured in compliance with all applicable requirements and specifications of the above purchase order and drawings except as noted below.

"Scratches" and "Point Defects" for the entire side 1 and side 2 surfaces were inspected using an high intensity white light source delivered perpendicular the surface. This was substituted for the method prescribed in specification E950104-A-D.

GENERAL OPTICS, INC.

By: _____

GENERAL OPTICS, INC. **PRECISION OPTICAL COMPONENTS**

554 FLINN AVENUE MOORPARK, CALIFORNIA 93021 (805) 529-3324 FAX (805) 529-4298

CERTIFICATE OF COMPLIANCE

Date: 07-07-97

To: Cal Tech

Purchase Order Number: PC203459

Part Number & Revision: D960791-A-D (w/Spec. #E950104-A-D)

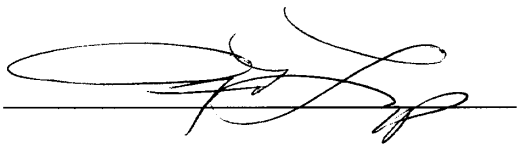
Part Description: Ligo End Test Mass Substrate

Serial Numbers: SP ETM 05A

We certify that the above part was manufactured in compliance with all applicable requirements and specifications of the above purchase order and drawings except as noted below.

"Scratches" and "Point Defects" for the entire side 1 and side 2 surfaces were inspected using an high intensity white light source delivered perpendicular the surface. This was substituted for the method prescribed in specification E950104-A-D.

GENERAL OPTICS, INC.

By: 

A. DCN: LIGO-T970014-00-D
B. LIGO S/N: ETMØ1-A

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: 11-03-97

G ☑ Verify glass polisher's Certification with LIGO Component Specification No. E960102-A-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 Electronic data available at CSIRO ftp site

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	9.87	in	250.75 mm
☑	Inspection of material thickness	Thickness	3.92	in	99.63 mm

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. Could not find packing slip

Inspection By: _____ Date Inspected: 11-04-97

Reviewed and/or accepted by:

Cognizant Engineer: _____ Date: _____

LIGO QA Officer or Designee: _____ Date: _____

FM300

Figure 1

LIGO DETECTOR OPTICS
Incoming Inspection Check-off Sheet

Core Optics Polished Substrate

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

SKETCHES:

DISPOSITIONS:

Substrate, End Test Mass	Serial Number: ETMØ1-A		Specification	Reported Value	✓
	Surface 1	Surface Figure Over Central 200mm	Spherical, Concave		✓
		Absolute Radius of Curvature Tolerance	7,400m + 150m - 150m	7.24 Km concave	✓
		Variation of Radius of Curvature from Average	+ 111m - 111m		
		Astigmatism	< 10nm p-v	2.3nm	✓
	Surface 2	Surface Figure Over Central 200mm	Flat	>1620 Km Concave	✓
		Radius of Curvature	> 80 Km		
		Astigmatism	< 64nm p-v	4.8nm	✓
	Surface Errors Surface 1	Low Spatial Frequency Band Central 80mm	$\leq 4.3\ cm^{-1}$ $\sigma_{rms} < 0.8nm$	0.46nm	✓
		Low Spatial Frequency Band Central 200mm	$\leq 4.3\ cm^{-1}$ $\sigma_{rms} < 1.6nm$	0.67nm	✓
		High Spatial Frequency Band Central 80 & 200 mm	$\leq 4.3 - 7.500\ cm^{-1}$ $\sigma_{rms} < 0.2nm$	0.16nm 0.17nm	✓

Scratches, Point Defects & Polish Side 1	Specification		Certification	✓
	Scratches	The Total Area of scratches within the central 80mm diameter shall not exceed 25 X 10^3 square micrometers (width x length). 8000	Hand Sketch w/dimensions	✓
		The total area of scratches outside the central 80 mm diameter shall not exceed 250 x 10^3 square micrometers. 8000	Hand Sketch w/dimensions	✓
	Point Defects	There shall be no more than 10 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
End Test Mass

		Specification	Certification	✓
Scratches, Point Defects & Polish Side 2	Scratches	The total area of scratches shall not exceed 1 X 10^6 square micrometers over the central 235 mm.	Hand Sketch w/dimensions	✓
	Point Defects	There shall be no more than 100 point defects within the central 80mm diameter.	Hand Sketch w/dimensions	✓
		There shall be no more than 300 point defects on the entire optic. 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
End Test Mass

This Certification Package relates to the following substrate: **End Test Mass**

Serial number: ETM01A

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
HABA - LIGO - C - SL:	Certification of Surface Errors - Low Frequency, for Side 1
HABA - LIGO - C - SH:	Certification of Surface Errors - High Frequency, for Side 1
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 2	Hard copy print out of LADI data for Side 2 with piston, tilt, removed
Attachment 3	Hard copy printouts of TOPO 2D data obtained with 2.5X and 40X heads at three central positions (side 1)

2. Electronic data

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

LADI data:	ETM1A1.ASC (Side 1)	ETM1A2.ASC (Side 2)
TOPO data: (2.5X)	T2EM011A.ASC, T2EM011B.ASC, T2EM011C.ASC (Side 1)	
(40X)	T4EM011A.ASC, T4EM011B.ASC, T4EM011C.ASC	

1	**Substrate Type:**	**End Test Mass**
2	**Serial Number:**	**ETM-01A**
3	**Physical quantity certified:**	**Physical Dimensions and Registration Mark**
4	**LIGO specification reference:**	**D960791-A-D**
5	**CSIRO measurement/inspection procedure reference:**	**HABA-LIGO-M-PD**
6	**Variations to the measurement/inspection procedure:** (indicate Yes/No and attach separate sheet if Yes)	**No**
7	**CSIRO Log Book Reference**	**LN00028, p.20**
8	**Team member responsible for measurement/inspection:**	**Carl Sona**
9	**Measurement/inspection results reviewed by:**	**Bob Oreb**

10. Results

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

Physical Quantity	Result
Diameter	250.75 mm
Cylindricity	0.02 mm
Thickness (maximum - for FM, RM, ETM) (minimum - for BS)	99.63 mm
Bevel as per drawing (height, angle):	(S1) Height:2.16 mm Angle: $44^0$50' (S2) Height:1.93 mm Angle: $44^0$50'
Wedge angle:	2^0 0'
Location of registration mark (± angle with respect to minimum part thickness):	+11'
Location of other 3 marks (with respect to registration mark at minimum thickness)	$90^0$0', $180^0$0', $269^0$58'
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: 22 October 97

1	**Substrate Type:**	**End Test Mass**
2	**Serial Number:**	**ETM-01A**
3	**Physical quantity certified:**	**Side and Bevel Polish**
4	**LIGO specification reference:**	**E960102-A-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**	**LN00024**
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").*

One scratch 2 mm in length on side

No defects on bevel

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: 22 · October 97

1	**Substrate Type:**	**End Test Mass**
2	**Serial Number:**	**ETM-01A**
3	**Physical quantity certified:**	**Serial Number and location**
4	**LIGO specification reference:**	**E960102-A-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**	**LN00024**
8	**Team member responsible for measurement/inspection:**	**E Pavlovic**
9	**Measurement/inspection results reviewed by:**	**J Seckold**

10. Results

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

11. Certification

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

Project Manager: Chris Walsh

Date: 22 Oct 97

1	**Substrate Type:**	**End Test Mass**
2	**Serial Number:**	**ETM-01A**
3	**Physical quantity certified:**	**Scratches and Point Defects**
4	**LIGO specification reference:**	**E960102-A-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**	**LN00024**
8	**Team member responsible for measurement/inspection:**	**E Pavlovic**
9	**Measurement/inspection results reviewed by:**	**A Leistner**

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	**none**	**none**	**8000**	**8000**
Surface 2	**none**	**none**	**none**	**none**

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: 27 Oct 97

1	**Substrate Type:**	**End Test Mass**
2	**Serial Number:**	**ETM-01A**
3	**Physical quantity certified:**	**Surface Figure**
4	**LIGO specification reference:**	**E960102-A-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)	**No**
7	**CSIRO Log Book Reference**	**LN00060, pp 102, 109**
8	**Team member responsible for measurement/inspection:**	**D Farrant**
9	**Measurement/inspection results reviewed by:**	**B Oreb**

10. Results

	Radius of Curvature in km	**Astigmatism (nm)**	**Electronic data file reference**
Surface 1	**7.24 (concave)**	**2.3**	**ETM1A1.ASC**
Surface 2	**> |620| (concave)**	**4.8**	**ETM1A2.ASC**

Hardcopies of the phase maps are attached to this certification as part of Attachment 1 for Side 1 and Attachment 2 for Side 2. 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). 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: 24 Oct. 97

1	**Substrate Type:**	**End Test Mass**
2	**Serial Number:**	**ETM-01A**
3	**Physical quantity certified:**	**Surface Errors - Low Spatial Frequency**
4	**LIGO specification reference:**	**E960102-A-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**	**LN00060, pp. 102, 109**
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	**0.46**	**0.67**
Surface 2	**N/A**	**N/A**

Hardcopies of the phase maps over the central 200 mm with piston, tilt, power and astigmatism removed are attached to this certification in Attachment 2 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: CWalsh Chris Walsh

Date: 27 Oct 97

1	**Substrate Type:**	**End Test Mass**
2	**Serial Number:**	**ETM-01A**
3	**Physical quantity certified:**	**Surface Errors - high spatial frequency**
4	**LIGO specification reference:**	**E960102-A-D**
5	**CSIRO measurement/inspection procedure reference:**	**HABA-LIGO-M-SH-B**
6	**Variations to the measurement/inspection procedure:** (indicate Yes/No and attach separate sheet if Yes)	**No, but note analysis procedures revised from that used on FM's**
7	**CSIRO Log Book Reference**	**LN00066, pp. 23-26, 48-51, 53**
8	**Team member responsible for measurement/inspection:**	**Frank Lesha**
9	**Measurement/inspection results reviewed by:**	**Chris Walsh**

10. Results

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

Side 1: **0.16 nm**

Side 2: **N/A**

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

Side 1: **0.17 nm**

Side 2: **N/A**

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

	A	B	C	D	E	F	G	H
Surface 1	**0.13**	**0.18**	**0.16**	**0.17**	**0.16**	**0.19**	**0.21**	**0.18**
Surface 2	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**

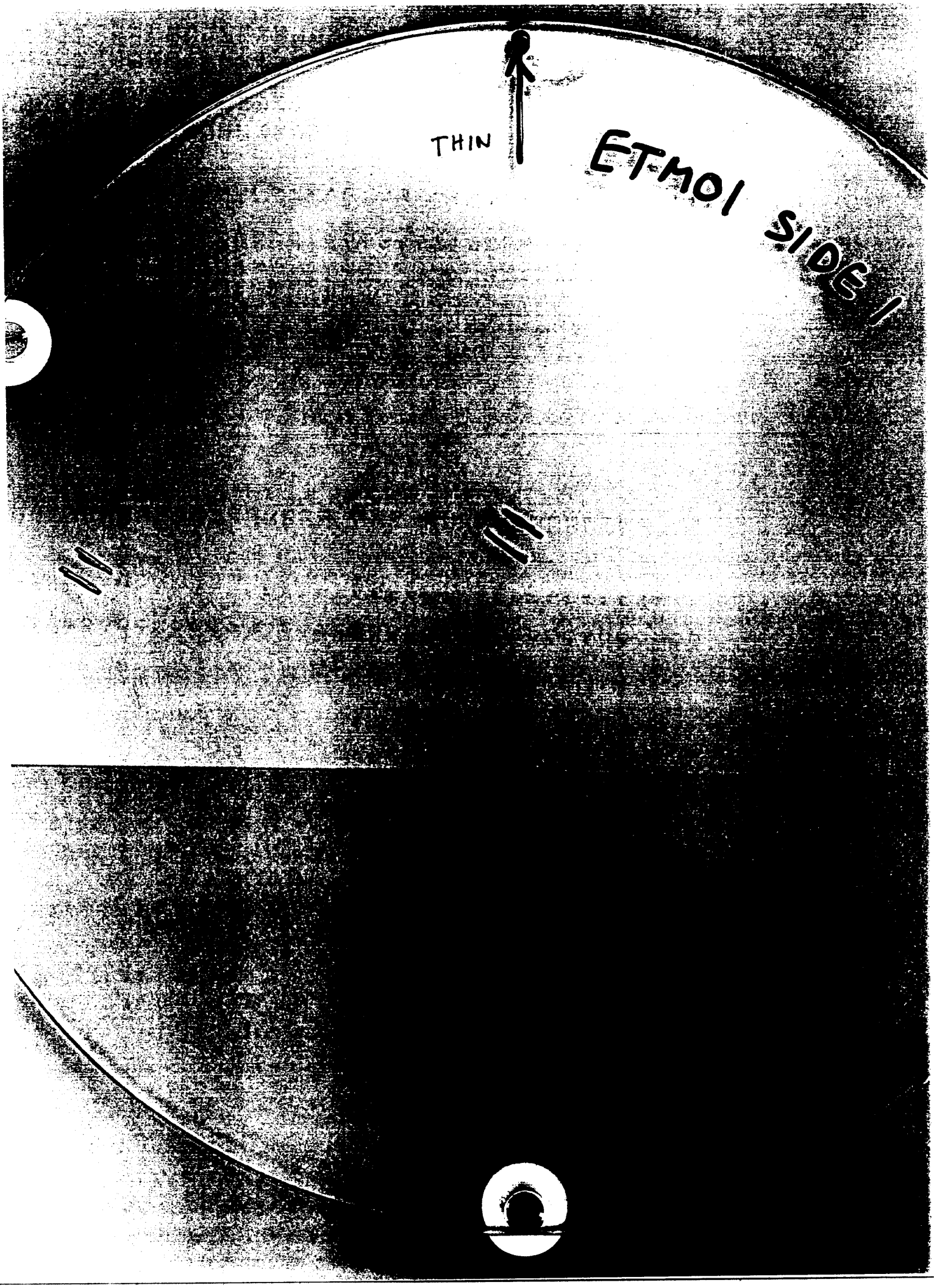
Two - dimensional surface maps at three central locations are available at the CSIRO ftp site under filenames of the form TOEM0YZA.asc, where O is the objective used (O=2 for 2.5X, 4 for 40X), EM refers to End Test Mass, 0Y is the number, Z = 1 or 2 is the side and A = A, B, C, ... is the sampling position. Hard copies of the data are at Attachment 3 (Side 1).

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: 27 Oct 97


THIN
ETMOI SIDE

LADI CERTIFICATION DATA

CSIRO

Title: ETM1A1

Date: 09/23/97

Diameter: 200 mm

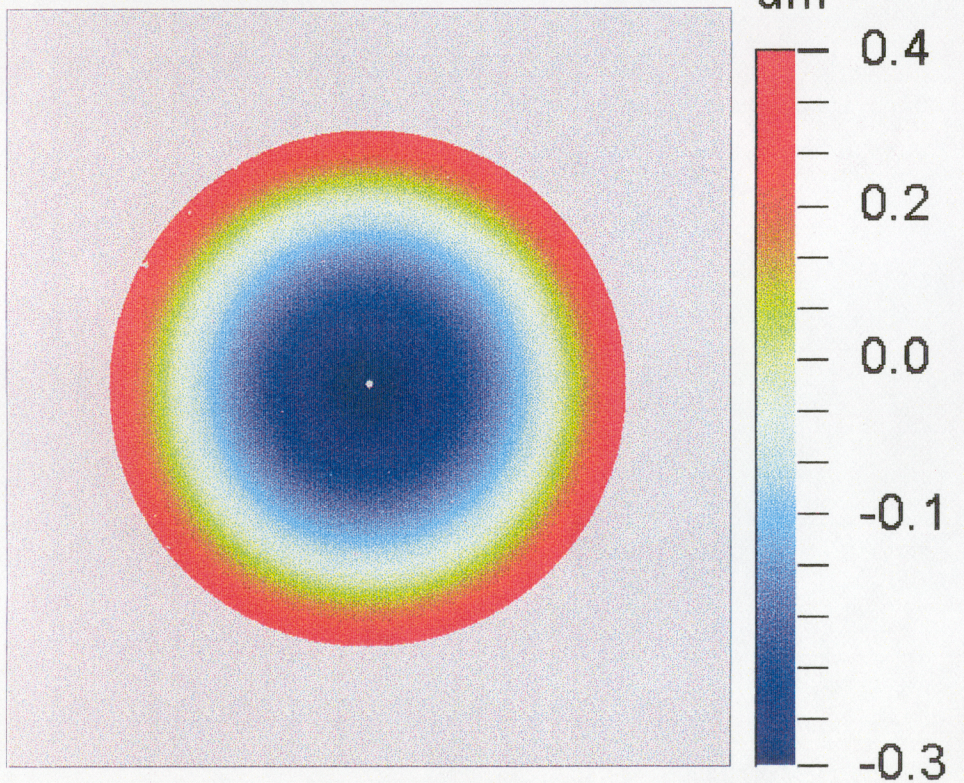
Astig: 2.3 nm

Power: 690.8 nm

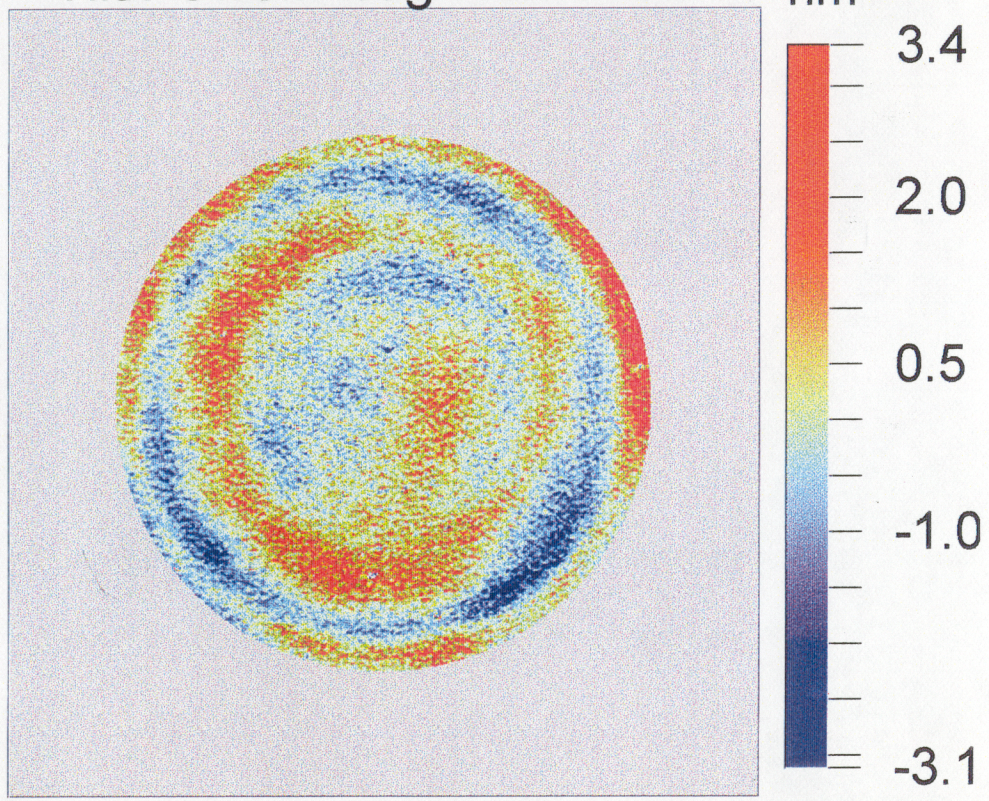
PV: 6.5 nm

RMS: 0.7 nm

Tilt Removed



Tilt/Power/Astig Removed



Attachment 1

LADI CERTIFICATION DATA

CSIRO

Title: ETM1A2

Date: 10/02/97

Diameter: 200 mm

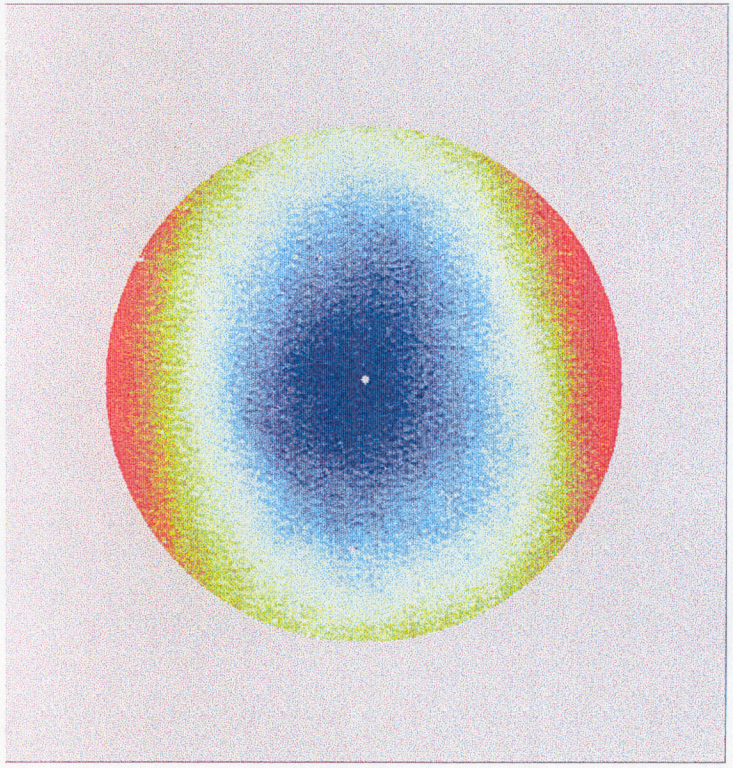
Astig: 4.8 nm

Power: 8.0 nm

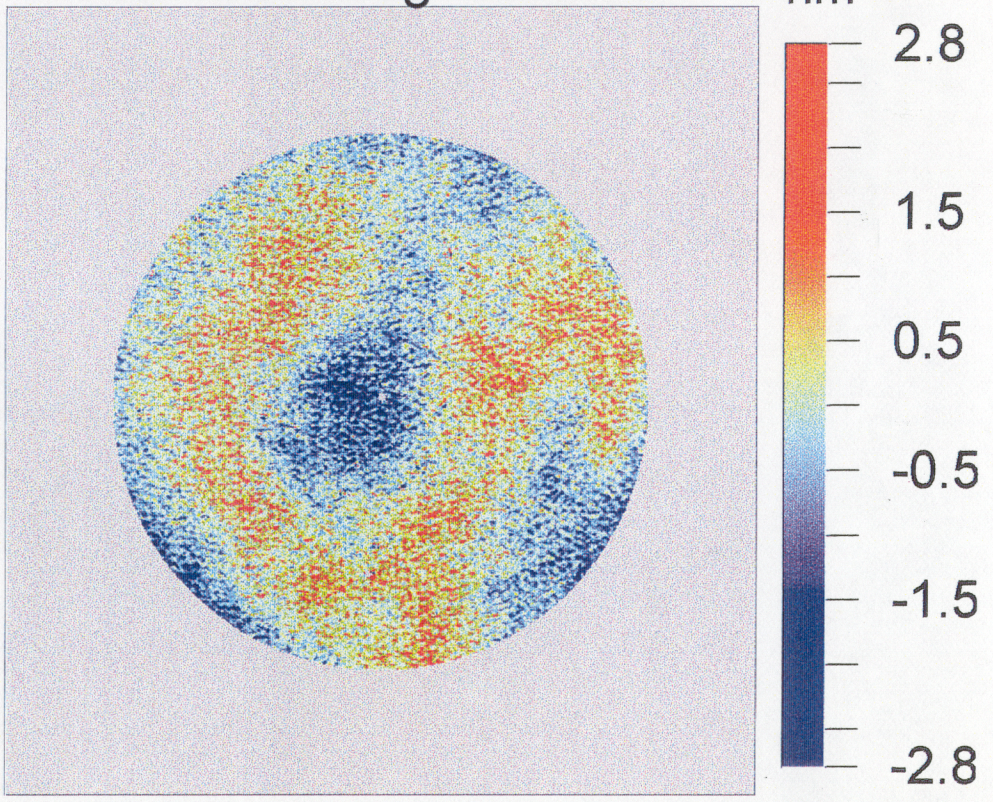
PV: 5.6 nm

RMS: 0.6 nm

Tilt Removed

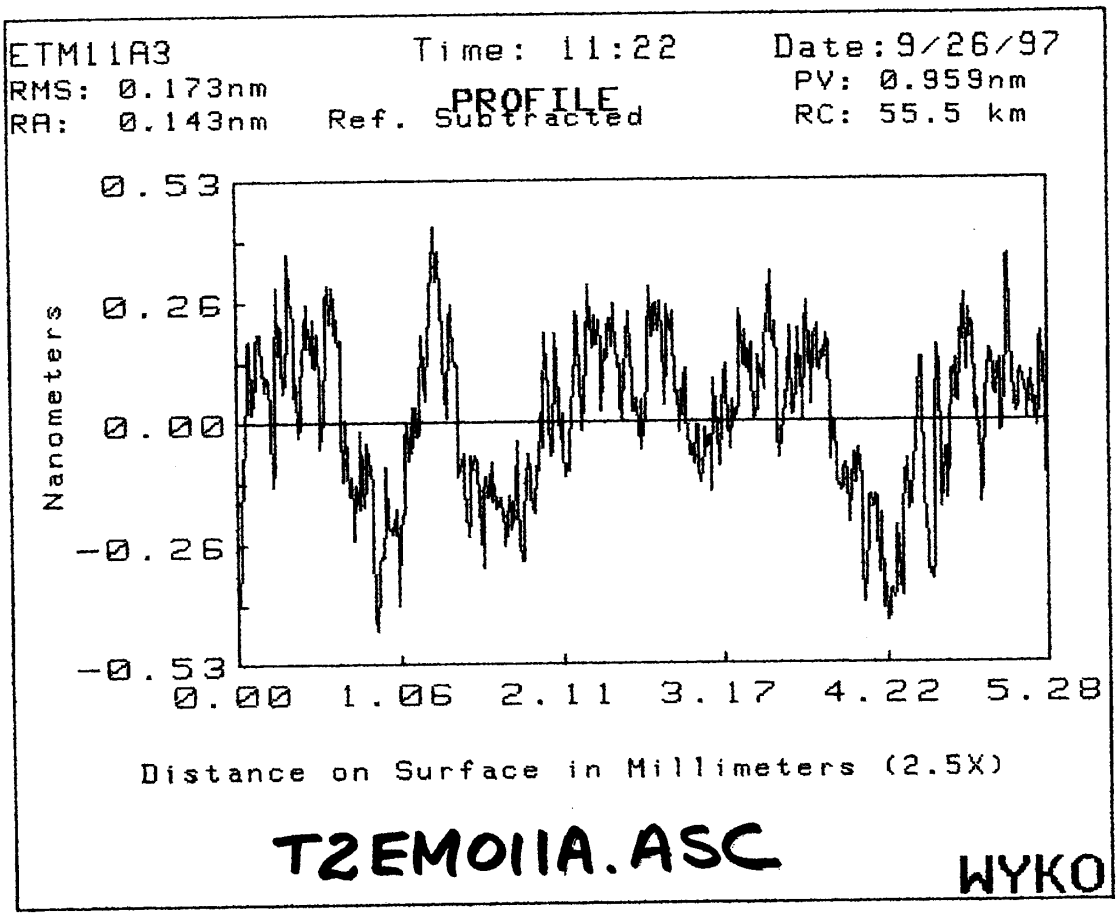


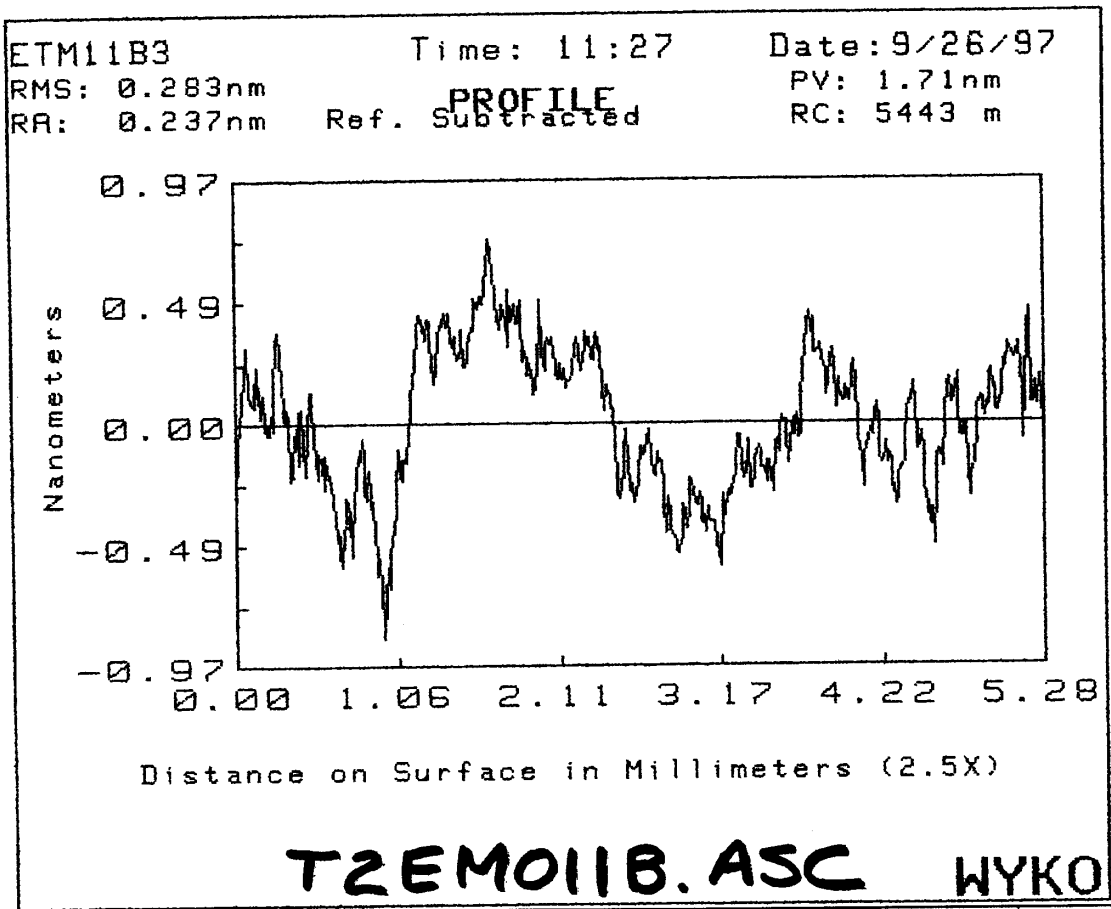
Tilt/Power/Astig Removed

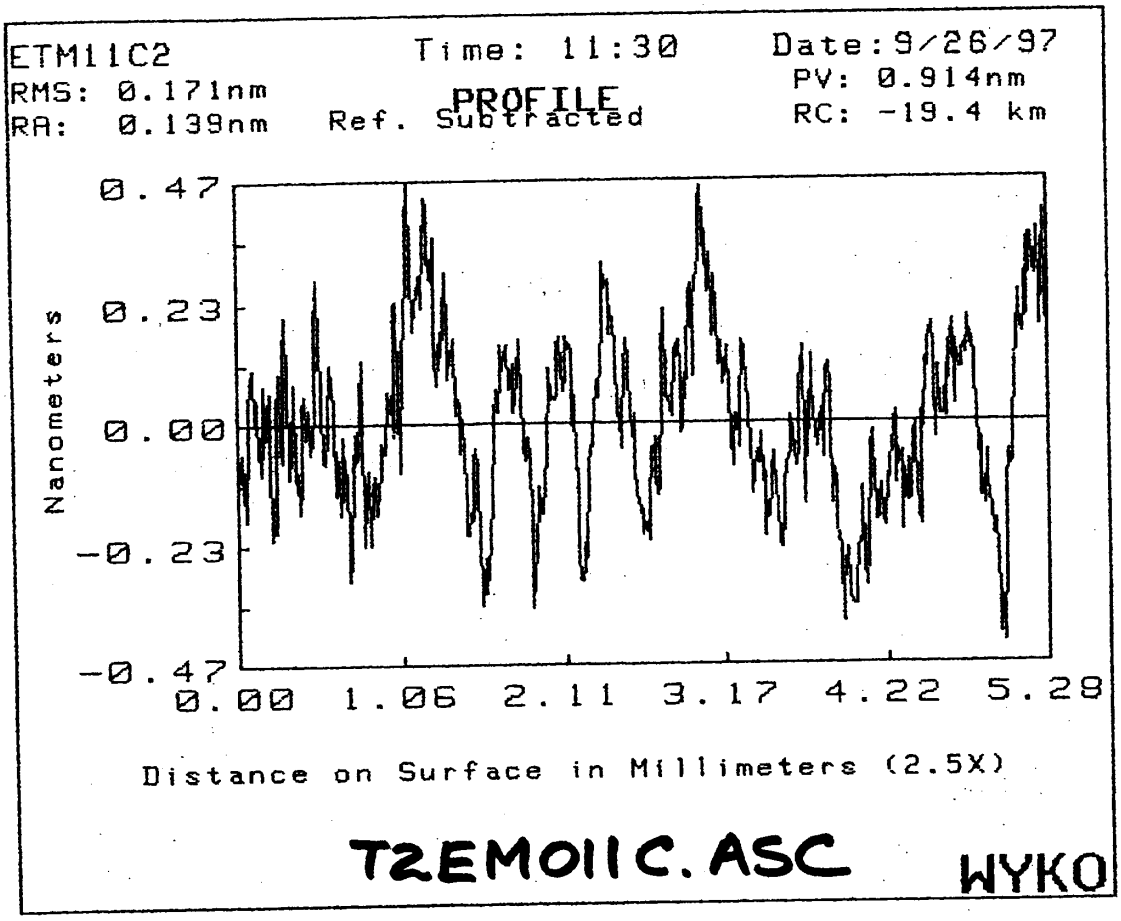


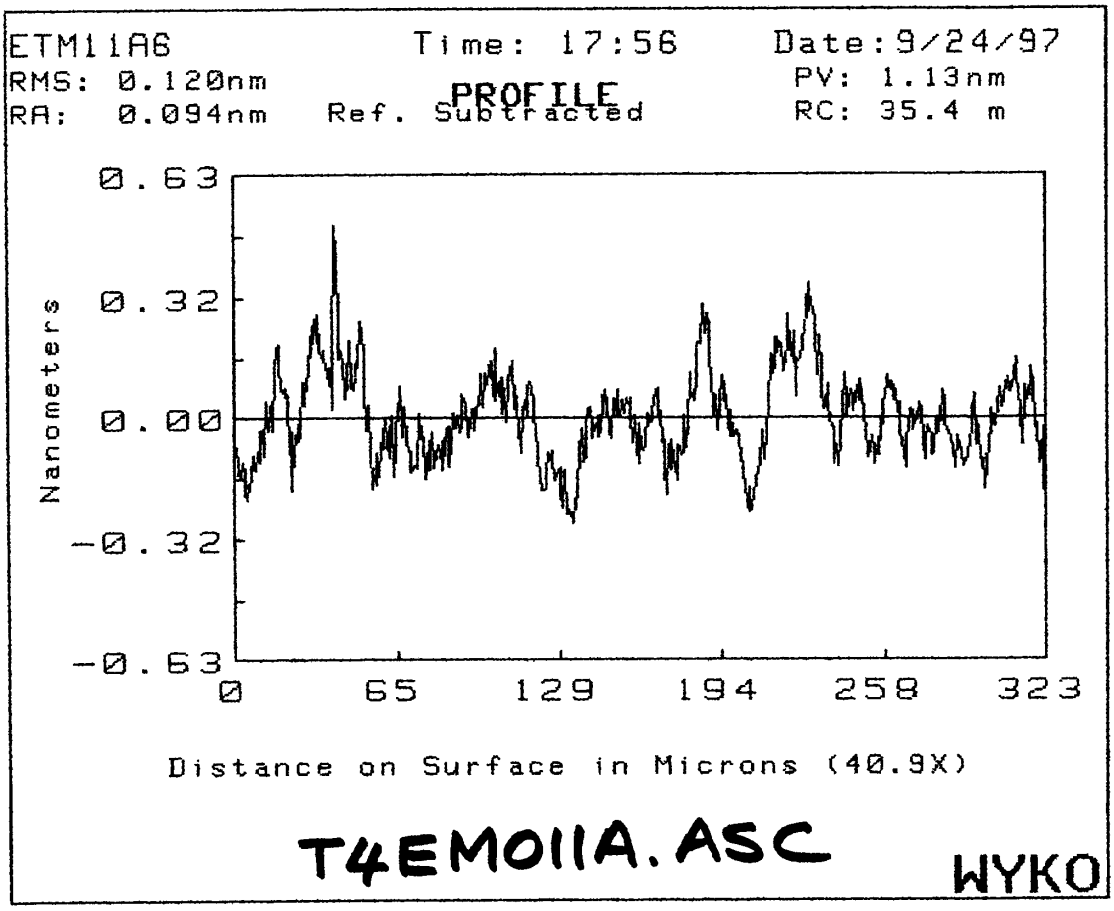
Attachment 2

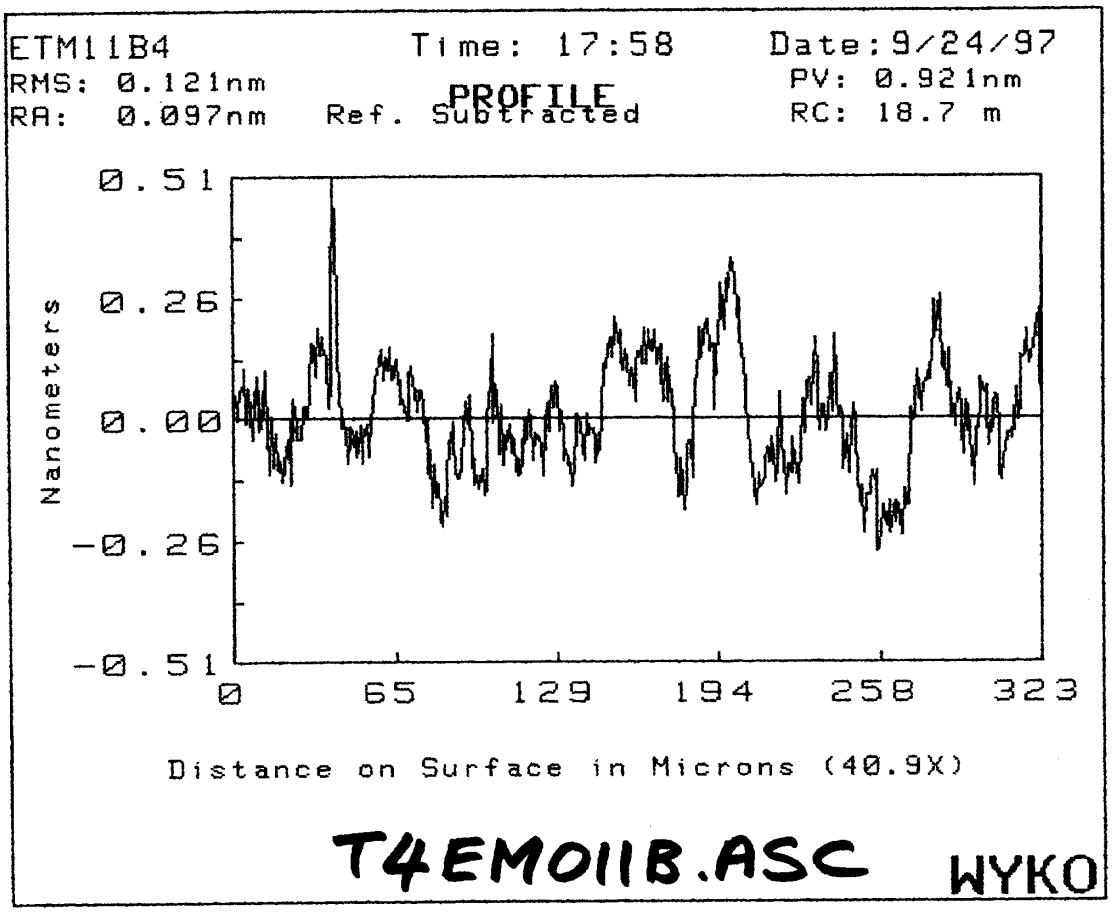
Attachment 3

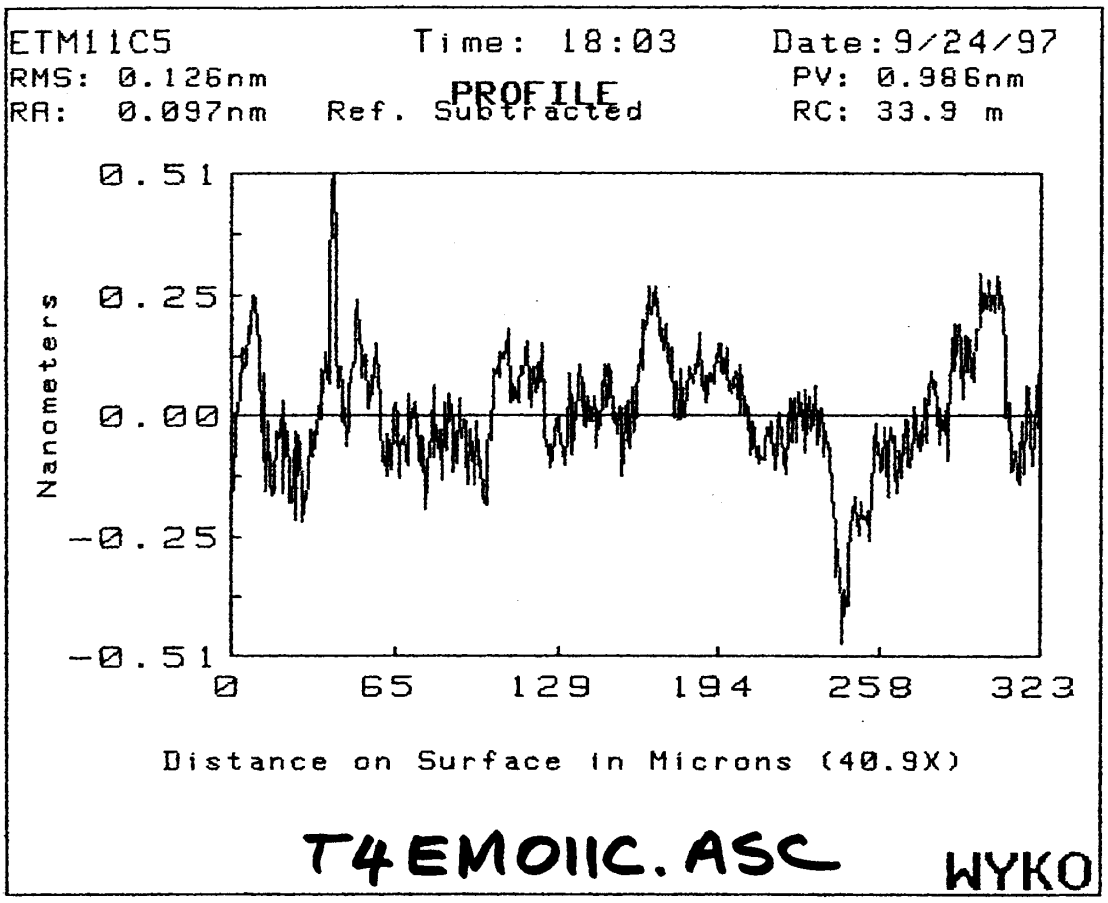





ETM11C2
Time: 11:30
Date:9/26/97
RMS: 0.171nm
PROFILE
PV: 0.914nm
RA: 0.139nm
Ref. Subtracted
RC: -19.4 km
0.47
0.23
0.00
-0.23
-0.47
Nanometers
0.00
1.06
2.11
3.17
4.22
5.28
Distance on Surface in Millimeters (2.5X)
T2EM011C.ASC
WYKO


ETM11A6
Time: 17:56
Date:9/24/97
RMS: 0.120nm
PROFILE
PV: 1.13nm
RA: 0.094nm
Ref. Subtracted
RC: 35.4 m
0.63
0.32
0.00
-0.32
-0.63
Nanometers
0
65
129
194
258
323
Distance on Surface in Microns (40.9X)
T4EM011A.ASC
WYKO


ETM11B4
Time: 17:58
Date:9/24/97
RMS: 0.121nm
PROFILE
PV: 0.921nm
RA: 0.097nm
Ref. Subtracted
RC: 18.7 m
0.51
0.26
0.00
-0.26
-0.51
Nanometers
0
65
129
194
258
323
Distance on Surface in Microns (40.9X)
T4EM011B.ASC
WYKO


ETM11C5
Time: 18:03
Date:9/24/97
RMS: 0.126nm
PROFILE
PV: 0.986nm
RA: 0.097nm
Ref. Subtracted
RC: 33.9 m
0.51
0.25
0.00
-0.25
-0.51
Nanometers
0
65
129
194
258
323
Distance on Surface in Microns (40.9X)
T4EM011C.ASC
WYKO


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 : MAY 26, 1998
  PO# PC165519
- Customer Name, Purchase Order No. : CALIFORNIA INSTITUTE OF TECHNOLOGY
- Customer Part Number & Revision : ETM LIGO-E980068-00-D
- Part Description : END TEST MASS COATED
- REO Job No. : OPT#5831-015 Run No.: RX739/0X742
- Qty. Shipped/Lot No. : 2 PIECES
  SERIAL #: 01 & 02

☐ **Test data (included)**

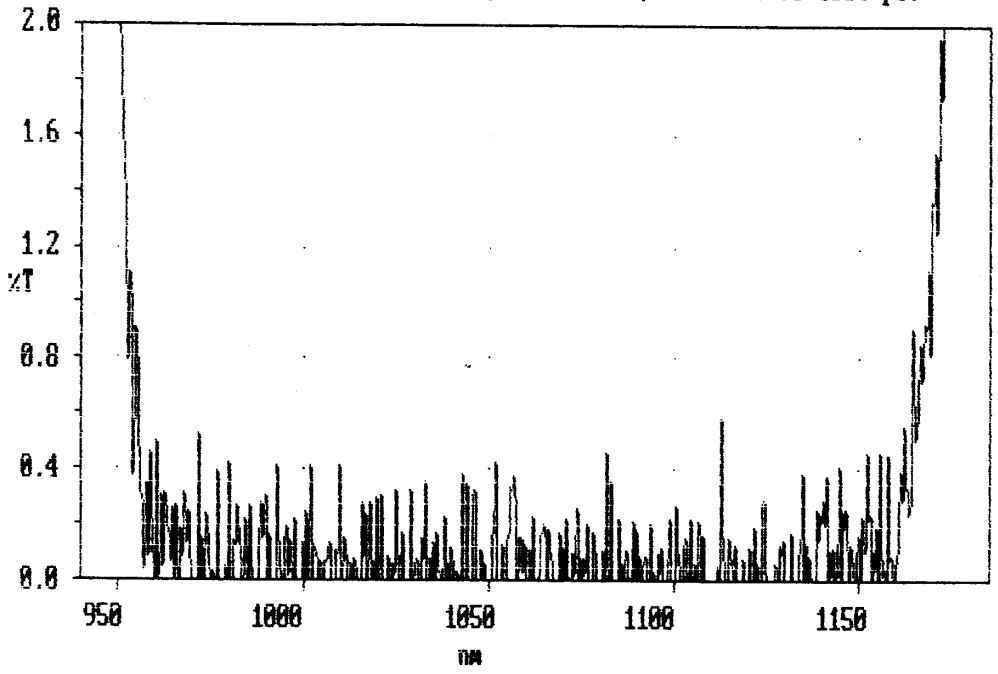
Comment:
WE'RE ALSO CHARGING CALTECH FOR 50% OF LIGO E980089, LIGOE980066 & LIGOE980067. (LINE# 36, 37 & 38)
P.O.#

Certified by: _____ 5/26/98
Quality Assurance

Verified by: Dale C Ness 5/26/98
Engr/Tech

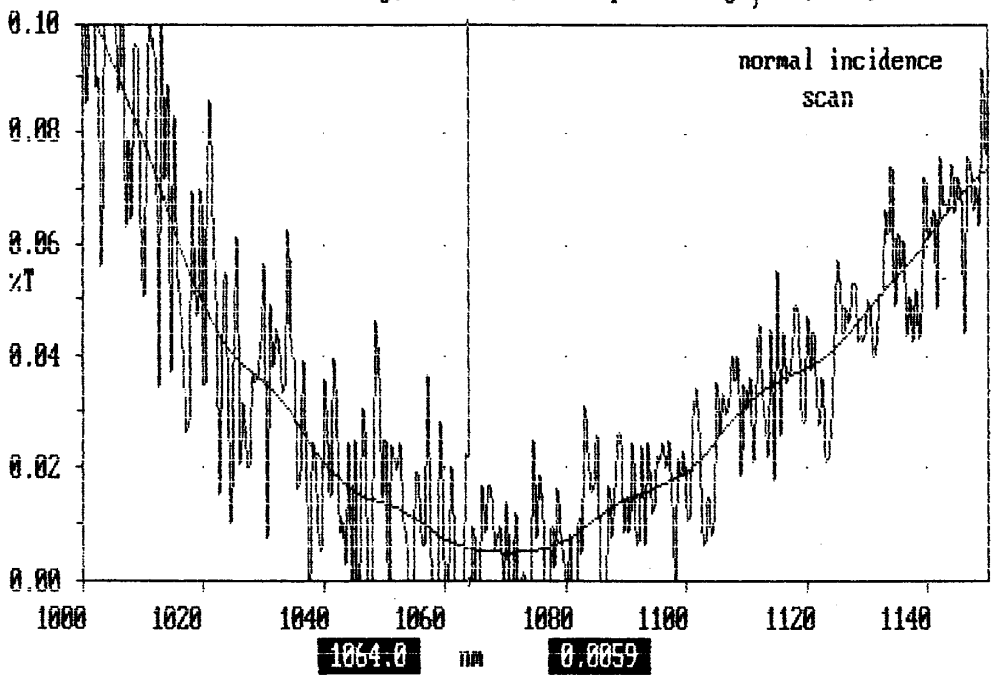
NOTE
Certificate must accompany the package to be shipped or attached to the outside of the same box to which the "Packing Slip" envelope is attached.

Y: user004; 1200.0 - 900.0 nm; pts 3001; int 0.10; ord -0.405 - 84.935 %T
Inf: Run #0X739, HR @ 1064, ETM01, ETM02, after bake, 1 " dia. FS Test pc.



$\lambda_c = 1048nm$

Y: user002; 1150.0 - 950.0 nm; pts 401; int 0.50; ord 0.0052 - 0.4697 %T
Inf: #0X742, AR at 1064nm at 2deg, witness, after processing , ETM01, ETM02



Research Electro-Optics, Inc.

PAGE NO: 1

INVOICE NO: [illegible]

INVOICE DATE: 05/26/1998

I N V O I C E

CUSTOMER NO: [illegible]
CUSTOMER PO: [illegible]-935-6201
SOLD TO:

CALIFORNIA INST. OF TECHNOLOGY
C PETRAC, M.S. 18-34 LIGO
51-33 EAST BRIDGE LABORATORY
PASADENA, CA 91125

YOUR ORDER NO: PC162519 CANCO
OUR ORDER NO: [illegible]
SHIP TO:

CALIFORNIA INST. OF TECHNOLOGY
51-33 EAST BRIDGE LAB.
MAIL CODE 18-34
PASADENA, CA 91125

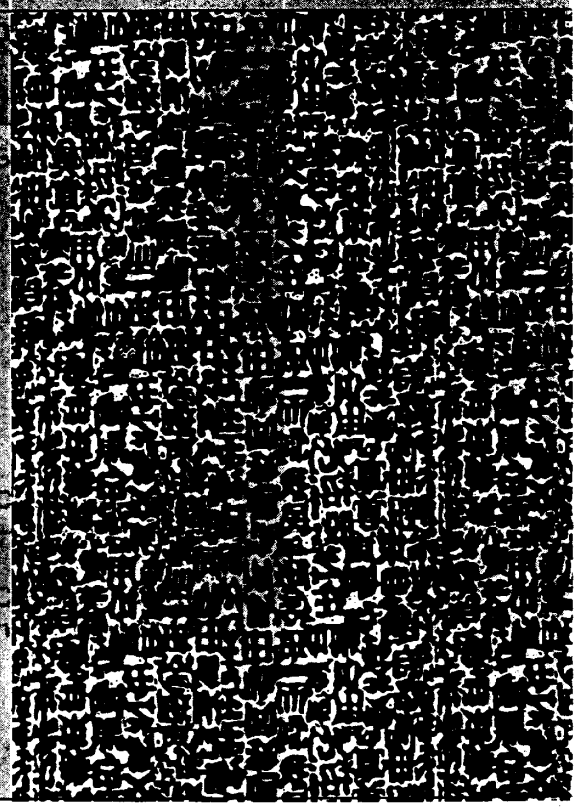
TERMS: CASH #1: DISC:
CASH #2: DISC:
NET DUE DATE: 06/25/98

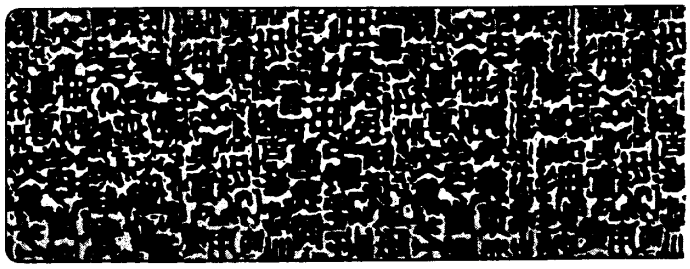
SHIPPED: 05/26/1998
SHIP VIA: FED-EX P1
F.O.B.: FACTORY
SHIPMENT NO: 005079 REF:
PRO NO:

YOUR CUSTOMER REP IS: JN

QTY ORDERED	QTY SHIPPED	QTY B.O.	ITEM NUMBER	UNIT PRICE	EXTD PRICE
			THIS ORDER IS A CHANGE ORDER TO REQ [illegible]		
			PER QUOTES OPQ 2403 & OPQ [illegible]		
			REFERENCE: CALTECH LIGO-C9[illegible]-00D LIGO-C98[illegible] LIGO-C950494-05		
			Technical Contact: Helena Armadula Tel: 626-395-2070 Mail Code 18-34		
			Contractual Representative: Irena Petrac Tel: 626-395-2975 Mail Code 18-34		
			Item: #001 thru' #014 is per PO# PC162519 C[illegible]		
			Item: #015 thru' #039 is per PO# PC162519 C[illegible] Per REQ quote #OPQ-2537. No Item #027 on th[illegible] acknowledgment.		
2	2	0	LIG[illegible]0068		
			END FIRST MASS. COATED		

ETMØ1





CONTINUED ON NEXT PAGE

Remit to: Accounts Receivable Department, P.O. Box 0543, Denver, CO 80256-0543
(303) 938-1960 FAX (303) 447-3279

PACKING LIST