SPETM03

LIGO-T990174-00-D

BLANK

T97011
[illegible]
FE Ø3

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.: F855306 SN-FEØ3
Manufacturer's Boule No.: 34640 BCT
Date Received at Caltech: 12-19-96

- [x] Verify glass manufacturer's Certification against LIGO Component Specification No. E960097-A-D Folding Mirror
- [x] Attach a copy of the glass manufacturer's Certification to check-off sheet.
- [x] Attach the glass manufacturer's optical phase maps supplied by vendor per above Component Specifications.
- [x] Visually inspect for shipping container damage. If applicable, describe damage on attached sheet and notify the Cognizant Engineer. Date Notified: NA
- [x] 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: ____________
- [ ] Verify core optic blank physical dimensions per applicable LIGO drawing.
    - [x] Inspection of material diameter. Diameter 10.110" 256.84 mm
    - [x] Inspection of material thickness. Thickness 4.291" 109.01 mm
    - [ ] ~~Inspection of chamfer~~. NA
- [x] Verify that the Registration Mark is present as required by LIGO Component Specification.
- [x] 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: ____________
- [x] Sign and date original packing slip (shipper) and distribute per paragraph 3.P.

Inspect By: [signature]   Date Inspected: 12-19-96

Reviewed and/or accepted by:

Cognizant Engineer: [signature]   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: _____

CORNING INCORPORATED

CORNING

CORNING, NEW YORK

SHIPPING ORDER

PACKING LIST

ORD. & DATE: C [illegible]07573 08/20/96

CNG ORD NO.: [illegible]

SOLD TO:
CALIFORNIA INSTITUTE OF TECHNO [illegible]
ACCOUNTS PAYABLE [illegible] 201-6 [illegible]
[illegible] CALIF BLVD
PASADENA, CA 911[illegible]

SAME AS "SOLD TO" UNLESS OTHERWISE SPECIFIED

SHIP TO:
CALIFORNIA INSTITUTE OF TECHNO [illegible]
ATTN MR LOWELL JONES
[illegible] S HOLLISTON [illegible]
PASADENA, CA 911[illegible]

SALES CODE: [illegible] 05[illegible]

DISCOUNT FACTOR:

DESIRED SHIP DATE: [illegible]/96

SHIPPED F.O.B.: CANTON, NY
[illegible] FOR DATE PPD TP INVOICED

DATE ENTERED: 08/29/96

WE EXPECT TO SHIP: 11/22/96

DATE SHIPPED	INVOICE NUMBER

DATE SHIPPED

ROUTING 52637

[illegible] WAY UPS Red

CAR INITIAL AND NUMBER

THIS SHIPMENT PARTIAL	THIS SHIPMENT COMPLETE	PREPAID	COLLECT
		X	

DATE ISSUED 12/18/96 DATE TO SHIP 12/18/96

WHSE. LOC. - PRODUCT CODE	DESCRIPTION	QUANTITY UNITS	QUANTITY CASES
[illegible]	[illegible] F S, O A 10 079"D X 4 252"T BLANK TOLERANCES + .040"/- .0[illegible]" BOTH DIMS FOLDING MIRROR, END TEST MASSES CLEAR APERATURE = 9.252" PRICE INCLUDES 2 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-E960097-4-D DWG# LIGO-D96079[illegible]	3 / BW	PC
855308 7950 0000	DISC, F S, OA, WITNESS SAMPLE, .984" X .284" CYLINDRICAL YOUR PRODUCT IDENT IS WITNESS SAMPLES WITNESS SAMPLES FOR ITEM 1 PRICE IS INCLUDED IN ITEM 001	3 / BW 32	PC

12-19-96

Rec'd 3 cartons in good Condition, Partial

[signature]

FE Ø3

ROUTING

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: 12/18/96

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, except parts approved for shipment in Deviation report.

FE Ø1
FE Ø2
FE Ø3

Signed: Brian C Bush

Brian C. Bush

Title: Quality Assurance Section Leader

Date: 12/18/96

DATA SHEET - CAL TECH LIGO MIRROR BLANKS

Cal Tech Purchase Order Number: PP 207573

Cal Tech Drawing Number: D960794

Attribute	Specification #	Requirement	Actual	Stamp	
Diameter	Per LIGO - D960097-A-D	10.079", -0.0"/+0.4"	10.111 / 10.111		QA
Thickness	Per LIGO - D960097-A-D	4.252";-0.0/+0.4"	4.2915/4.2915/4.2915/4.2915		QA
Registration Mark	Per LIGO - D960794	TOP CENTER OF OPTIC	See Attached Cert.		M
Serial & Boule #	Per LIGO-D960794	Boule & Serial No.	34640BCT-FE03		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		P.TOV.<----1----x10E-6	1.75E x 10-7 PV - 0.030		M
Homogeneity - outside		P.TOV.<-2.5-x10E-6	5.32E x 10-7 PV - 0.092		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: 12-17-96

zygo — Homogeneity

Lg Aperture

PV 0.028 wave

rms 0.005 wave

Power 0.021 wave

Homogeneity 1.63E-07

Points 1257

AstMag (Z) 0.020 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 1256 data points

Order: 10th Terms: 36 rms: 0.001

```
-0.046  0.023 -0.057  0.010
-0.008  0.006 -0.002  0.002 -0.001
-0.001 -0.005  0.000  0.001  0.000  0.000  0.002
 0.000  0.000  0.000  0.002  0.001  0.000  0.000  0.000 -0.001
 0.000  0.001  0.000 -0.001  0.000  0.000  0.000 -0.001 -0.001
```

Measure | Mask Data | Save Data | DBSAVE

Analyze | Calibrate | Load Data

zygo — File Data

Subtract Sys Err: On

Sys Err File: r111596.802

Part Thickness: 4.29 in

Boule #: 34640

Suffix: BCT

Min Mod (%): 1

Phase Res: High

Scale: 0.500

AGC: Off

Light Level: 110

Comment:

CALIF INST TECH SN FE03

Data File: 34640BCT.dat

Camera Res: 1.9600 mm

Time: Sat Dec 07 22:36:54 1996

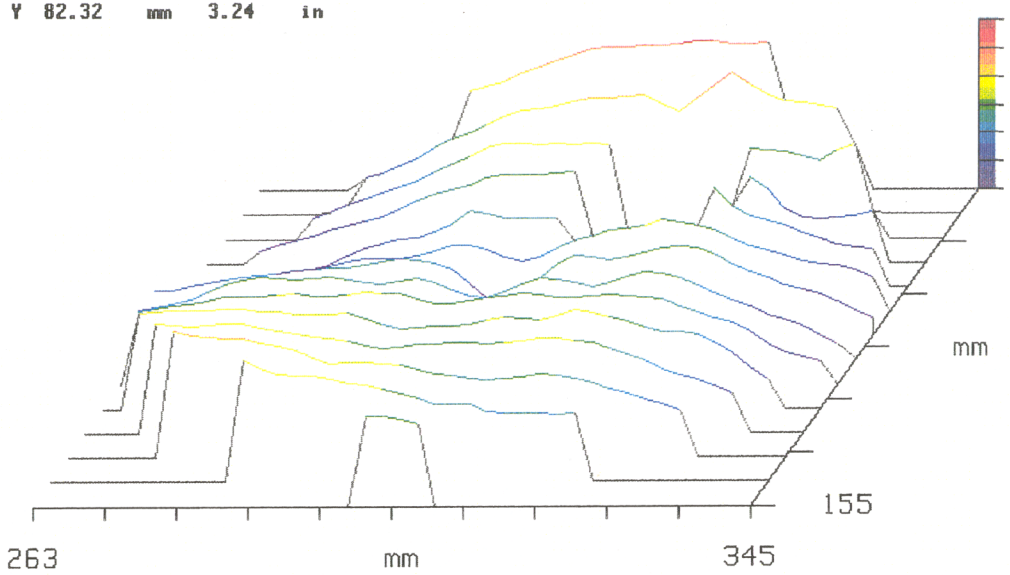
Phase Avgs: 6

Intens Avgs: 6

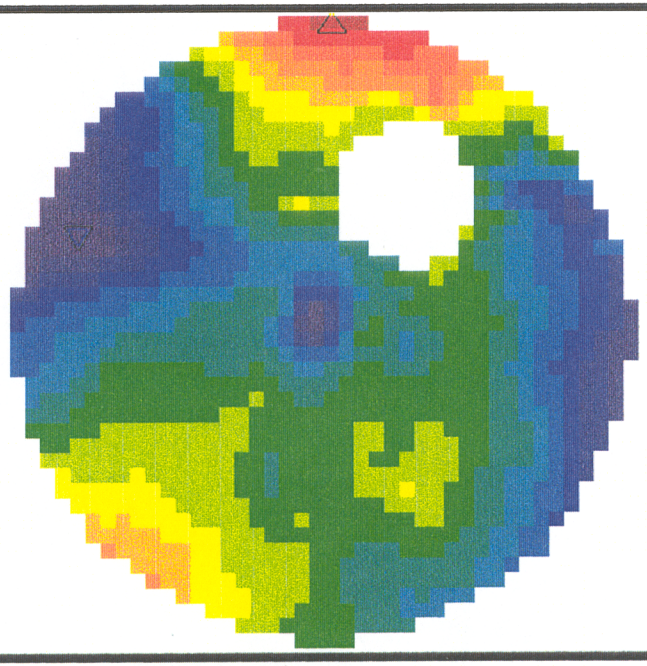
Corning Inc. Canton Plant Metrology Dept. 334 Co. Rt. 16, Canton, NY 13617 (315) 379-3283

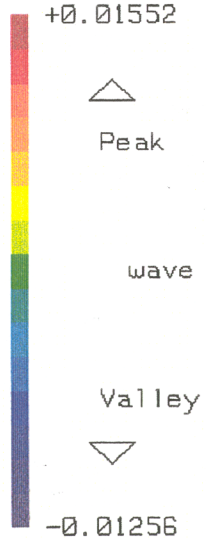
Size X 82.32 mm 3.24 in

Size Y 82.32 mm 3.24 in



Save Subapt





SlopeMag | TiltXY | Filter | AutoSeq | Manipulate | Metroscript

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

zygo — Homogeneity

Lg Aperture

PV 0.088 wave

rms 0.017 wave

Power 0.092 wave

Homogeneity 5.10E-07

Points 8169

AstMag (Z) 0.077 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 8168 data points

Order: 10th **Terms:** 36 **rms:** 0.002

```
-0.005  0.055 -0.136  0.045
-0.022  0.031  0.002 -0.002 -0.007
 0.003 -0.007  0.011 -0.005  0.003  0.001  0.001
-0.006  0.011 -0.002  0.004 -0.004  0.001  0.001  0.003  0.000
-0.001 -0.005  0.002 -0.003 -0.001 -0.004 -0.001  0.002  0.001
```

Measure | Mask Data | Save Data | DBSAVE

Analyze | Calibrate | Load Data

zygo — File Data

Subtract Sys Err: On | Min Mod (%): 1

Sys Err File: r111596.802 | Phase Res: High

Part Thickness: 4.29 in | Scale: 0.500

AGC: Off

Boule #: 34640 | Light Level: 110

Suffix: BCT

Comment:

CALIF INST TECH SN-FE03

Data File: 34640BCT.dat | Phase Avgs: 6

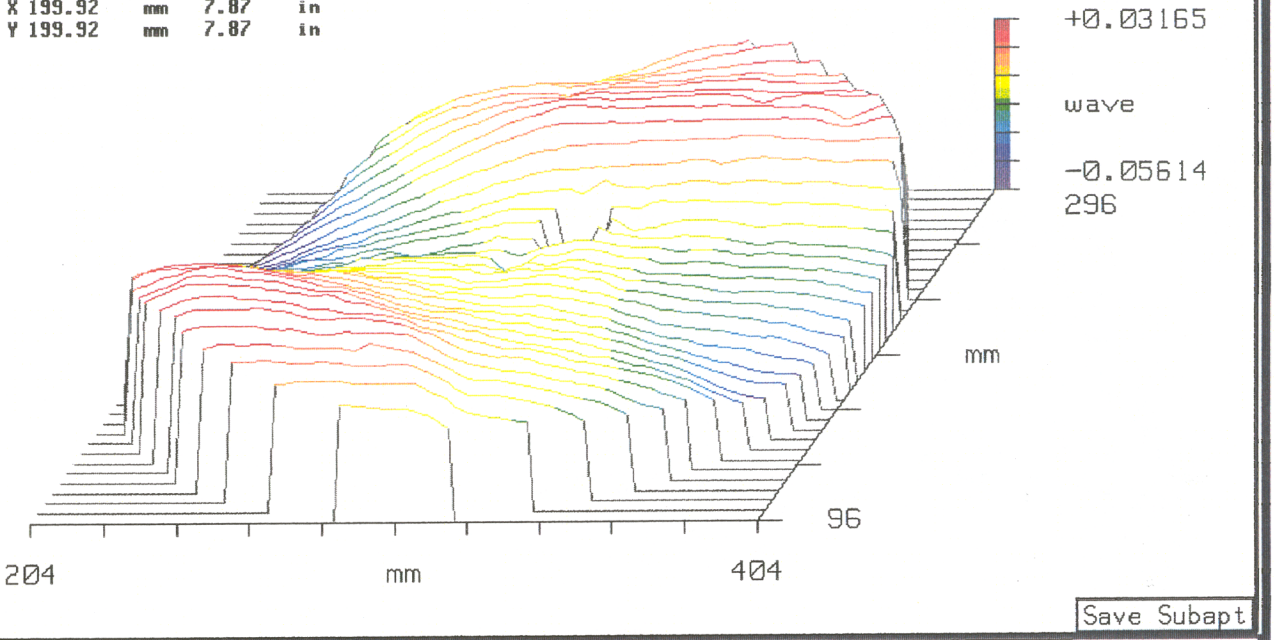
Camera Res: 1.9600 mm | Intens Avgs: 6

Time: Sat Dec 07 22:36:54 1996

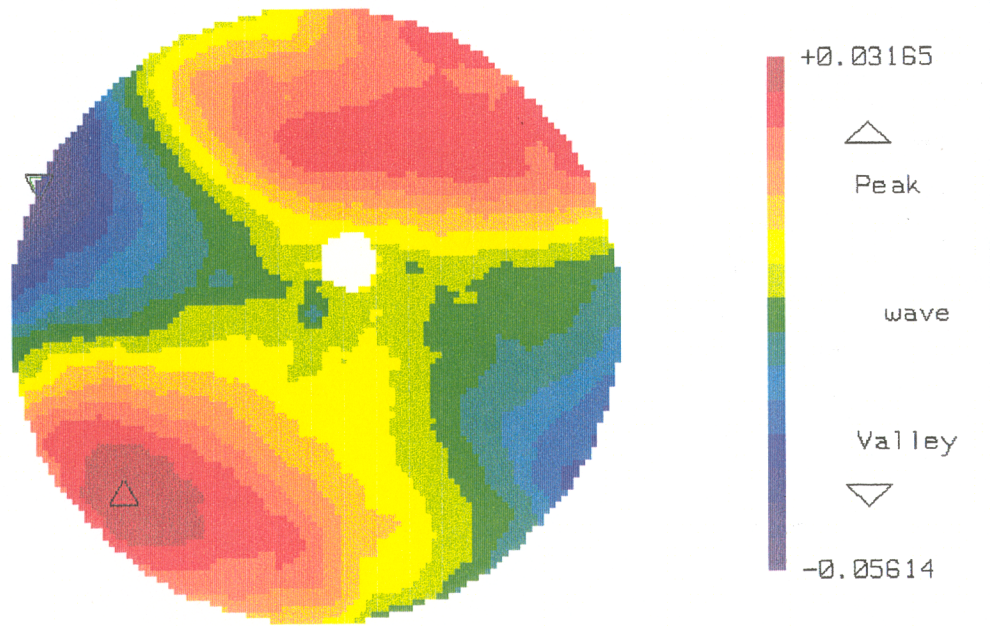
Corning Inc. Canton Plant Metrology Dept. 334 Co. Rt. 16, Canton, NY 13617 (315) 379-3283

Size X 199.92 mm 7.87 in

Size Y 199.92 mm 7.87 in

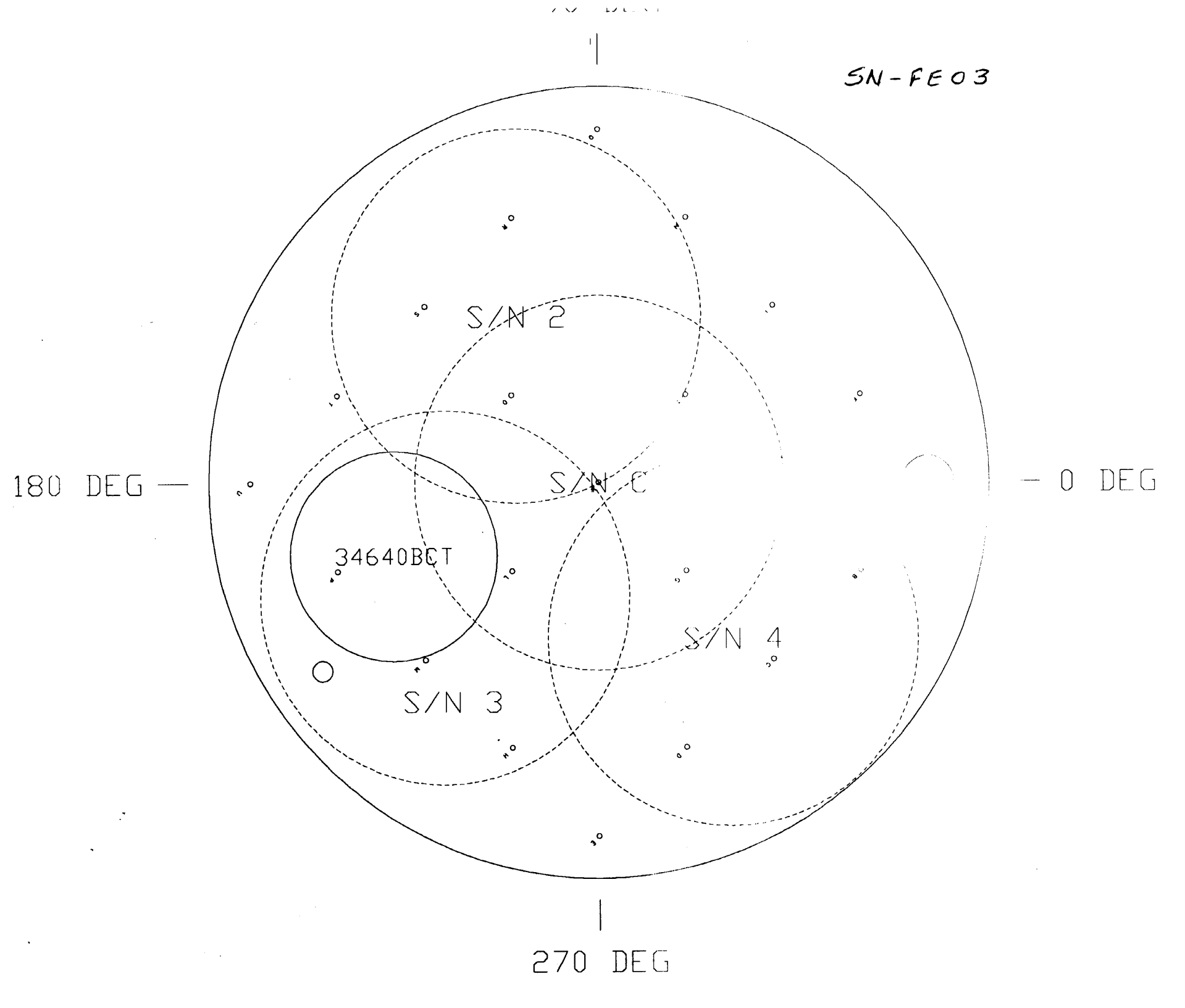


Save Subapt



SlopeMag | TiltXY | Filter | AutoSeq | Manipulate | Metroscript

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


SN-FE03
S/N 2
S/N C
S/N 4
S/N 3
34640BCT
180 DEG
0 DEG
270 DEG

DEVIATION APPROVAL FORM

Customer Name: California Inst. Technology

Customer P.O. Number: PP 207573

Corning Order Number: QD106 34801

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)

OK BB 1-24-97

Randy VanBeek
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 Ø3
(sequential number) - (year)

cc: Shipping Clerk
Customer Service

Q704 rev. A

pertains to serial numbers
FE01 — FE09 - GB

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

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: _____

A. DCN: LIGO- T97011-00-D
B. LIGO S/N: SP ETMØ3A

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.: PC 203459 D. Substrate Polisher: General Optics

E. Core optic Material: BS / FM / 2ITM / 4ITM / (ETM) SP / RM F. Date Received: Shipped direct to NIST

G ☑ Verify glass polisher's Certification with LIGO Component Specification No. E950104-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 NA

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 NA

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. NA

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

☑	Inspection of material diameter.	Diameter	_____ in	250.061	mm
☑	Inspection of material thickness	Thickness	_____ in	99.863	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. NA

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. NA

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.) SPETM C3

Large Dubble veer surface 1 x 1½" in from edge guess grade 50

Scratches and point defects were not reported.

SKETCHES:

DISPOSITIONS:

Ligo Test Mass
Drawing Number D960791-A-D
Specification Number E950104-A-D
Serial Number SP ETM 03 A

Final Inspection report

June 7, 1997

Feature	Requirement	Actual	
Side 1			
Spherical Measurement	< 1/20 Wave Concave	.023 Waves PV	
Radius of Curvature	7400 M +/- 220 M	7456.61 M	
Micro-Roughness	< 1.0 Angstrom	0.49 Angstroms	
Surface quality	< 10 Defects Entire Surface	Verified	
Side 2			
Flatness	< 1/10 Wave	0.063 Waves PV	39.9 nm
Micro-Roughness	< 1.0 Angstrom	0.38 Angstroms	
Surface quality	< 10 Defects Entire Surface	Verified	
Substate Features			
Diameter of -A-	250 mm +1mm/-0 mm Dia	250.061 mm	
Thickness	100 mm + 0/-.5 mm	99.863 mm Sharp Corner	
Wedge, Surface 2	2 Degrees +/- 5 Min	1.989 Degrees	
Chamfers, After Polish			
Side 1	2 mm +/- 0.3 mm, 2 Plc's	2.12 mm	
Side 2	2 mm +/- 0.3 mm, 2 Plc's	1.80 mm	

Substrate, End Test Mass	Serial Number: SP ETM Ø3		Specification	Reported Value	✓
	Surface 1	Surface Figure Over Central 200mm	Spherical, Concave	.023 waves PV	✓
		Absolute Radius of Curvature Tolerance	7,400m + 220m - 220m	7456.61 m	✓
		Variation of Radius of Curvature from Average	+ 111m - 111m		
		Astigmatism	< 10nm p-v		
	Surface 2	Surface Figure Over Central 200mm	Flat < 1/10 wave	0.063 waves PV (39.9 nm)	✓
		Radius of Curvature	> 80 Km		
		Astigmatism	< 64nm p-v		
	Physical Dimensions	Substrate Diameter	250mm +1mm/-0mm	250.061 mm	✓
		Substrate Thickness	100mm +0/-.5mm	99.863 mm	✓
		Wedge Angle, Surface 2	2° ±min	1.989°	✓
		Chamfers, After Polish			
		Side 1	2mm ±0.3mm	2.12 mm	✓
		Side 2	2mm ±0.3mm	1.80 mm	✓
	Surface Errors Surface 1	Low Spatial Frequency Band Central 80mm	≤ 4.3 cm^{-1} σ_{rms} < 0.8nm		
		Low Spatial Frequency Band Central 200mm	≤ 4.3 cm^{-1} σ_{rms} < 1.6nm		
		High Spatial Frequency Band Central 80 & 200 mm	4.3 – 7,500 cm^{-1} σ_{rms}<0.2nm		

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).	Hand Sketch w/dimensions	
		The total area of scratches outside the central 80 mm diameter shall not exceed 250 x 10^3 square micrometers.	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	

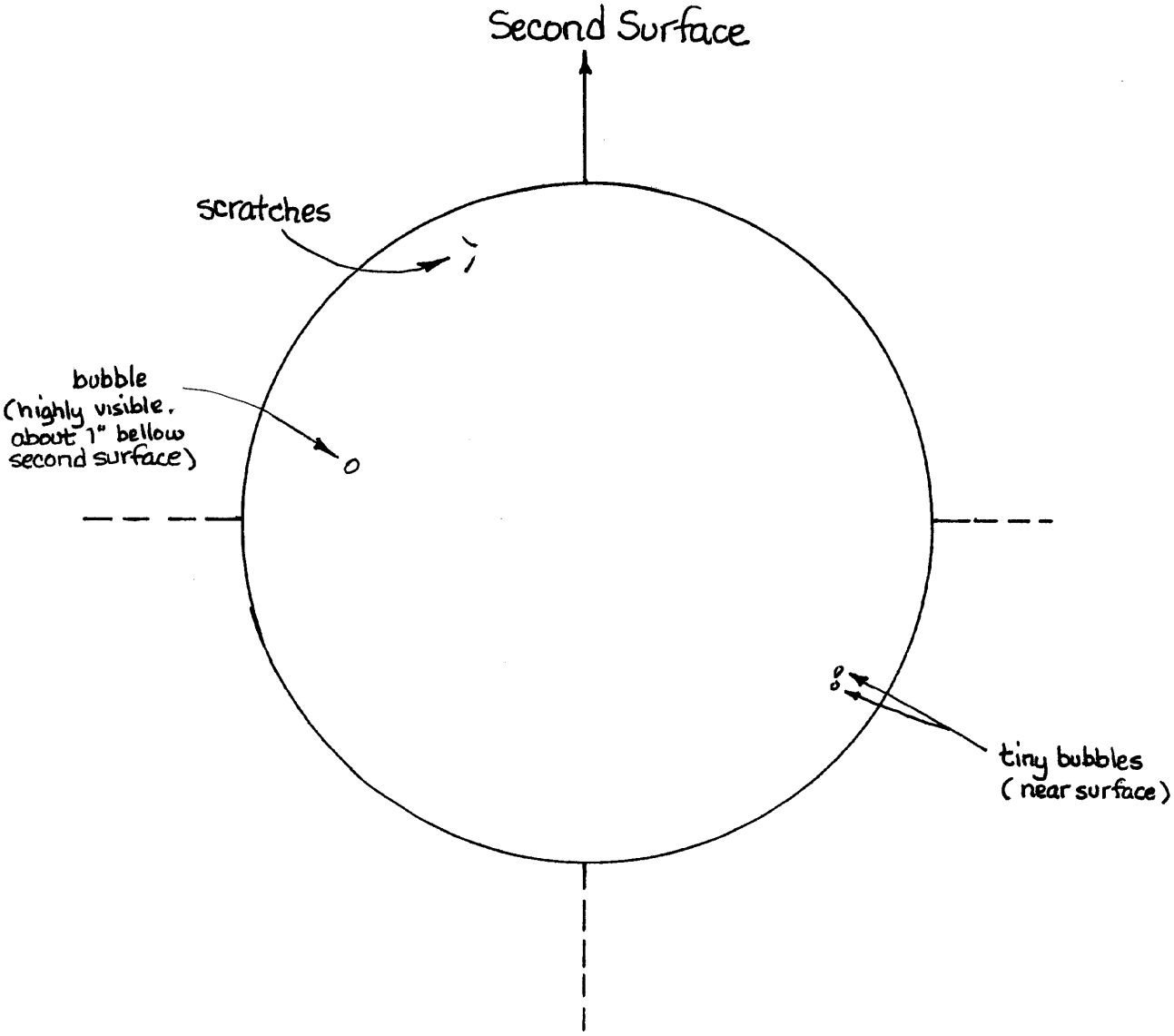
LIGO Component Specification Verification Sheet
End Test Mass

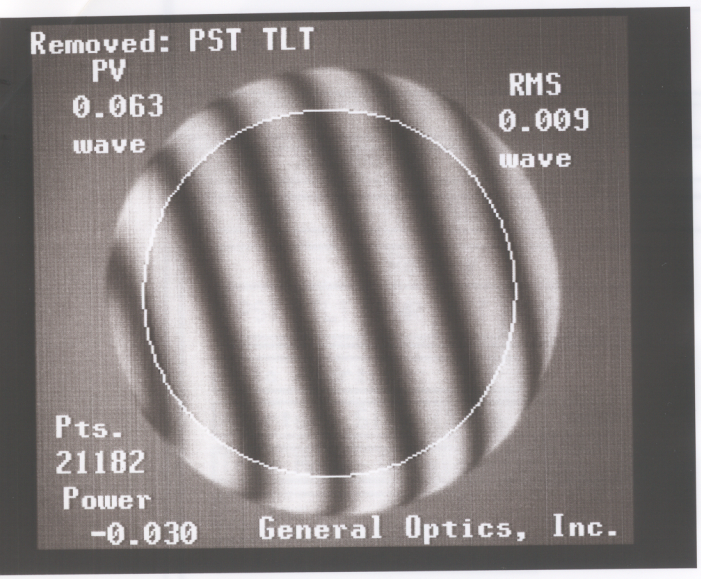
		Specification	Certification	✓
Scratches, Point Defects & Polish Side 2	Scratches	The total area of scratches shall not exceed 1 X 10^6 square micrometers over the central 235 mm.	Hand Sketch w/dimensions	
	Point Defects	There shall be no more than 100 point defects within the central 80mm diameter.	Hand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

Serial No: SPETMØ3-A (Polished by G.O.)
Date: 09-02-97

Viewed with high intensity fiber optic. Substrate placed vertically on table in the Laminar flow hood.





zygo General Optics, Inc. 554 Flinn Ave, Moorpark, CA 93021 805) 529-3324

zygo Oblique Plot

+0.0295
wave
-0.0332
9.4
in
1.5
10.2

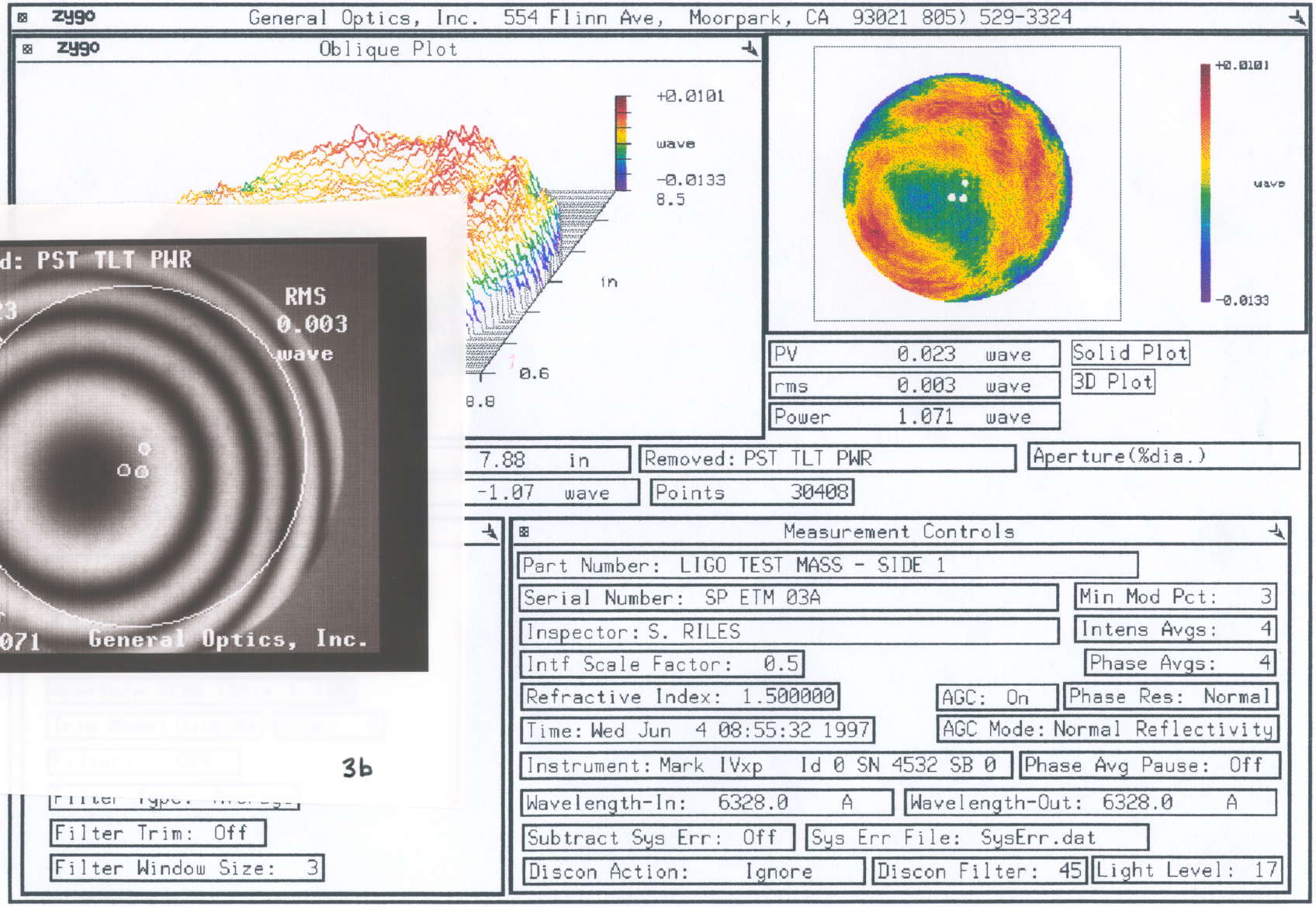
+0.0295
wave
-0.0332

PV	0.063	wave	Solid Plot
rms	0.009	wave	3D Plot
Power	-0.030	wave	

7.87 in	Removed: PST TLT	Aperture(%dia.)
0.03 wave	Points 21182	

Measurement Controls

Part Number: LIGO TEST MASS - SIDE 2			
Serial Number: SP ETM 03A		Min Mod Pct:	3
Inspector: J. LONGO		Intens Avgs:	4
Intf Scale Factor: 0.5		Phase Avgs:	4
Refractive Index: 1.500000	AGC: On	Phase Res:	Normal
Time: Wed Jun 4 11:23:51 1997	AGC Mode: Normal Reflectivity		
Instrument: Mark IVxp Id 0 SN 4532 SB 0		Phase Avg Pause:	Off
Wavelength-In: 6328.0 A	Wavelength-Out: 6328.0 A		
Subtract Sys Err: Off	Sys Err File: SysErr.dat		
Discon Action: Ignore	Discon Filter: 45	Light Level:	34

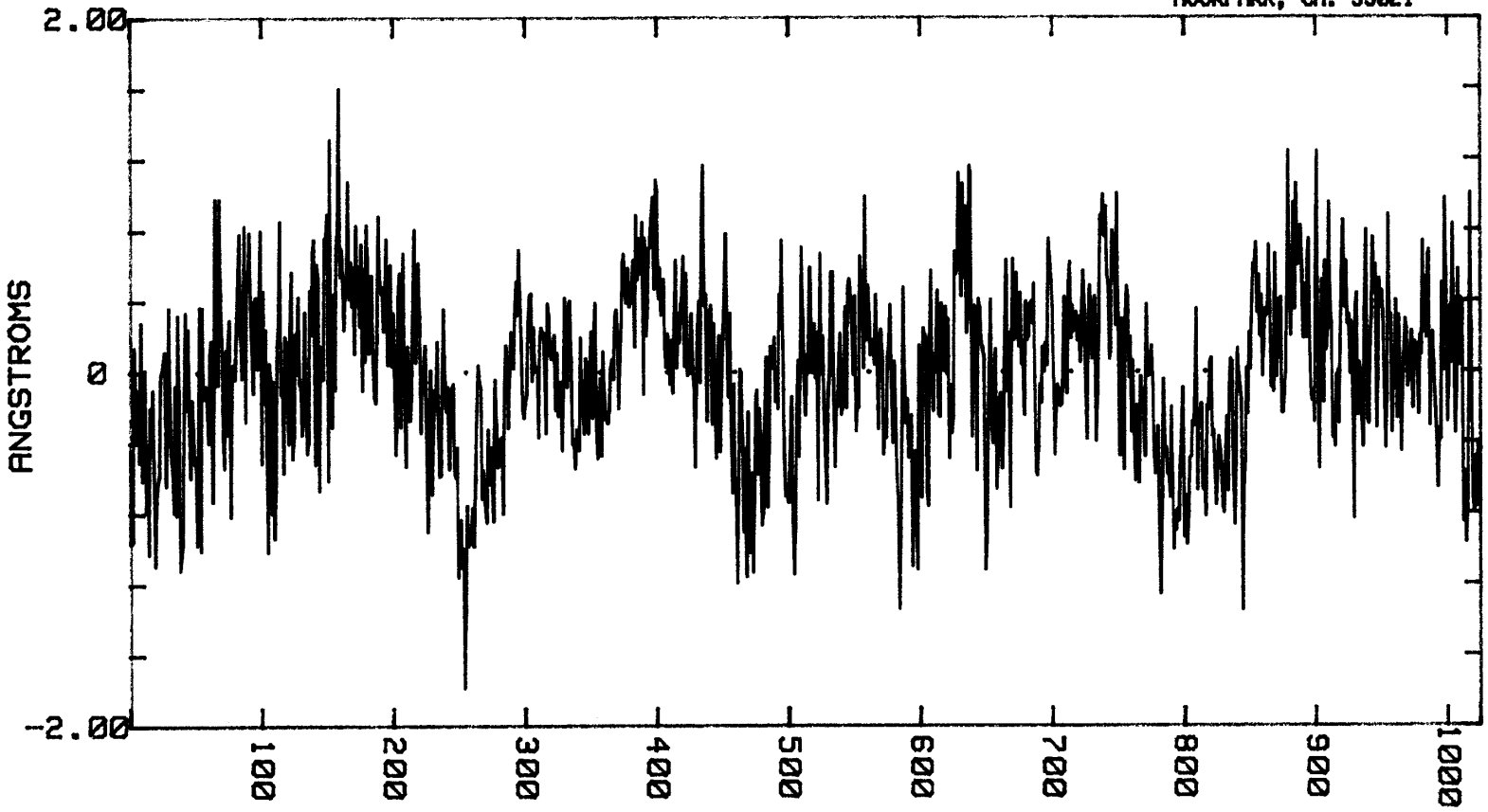

zygo
General Optics, Inc. 554 Flinn Ave, Moorpark, CA 93021 805) 529-3324
zygo
Oblique Plot
+0.0101
wave
-0.0133
8.5
in
0.6
8.8
+0.0101
wave
-0.0133
PV 0.023 wave
rms 0.003 wave
Power 1.071 wave
Solid Plot
3D Plot
7.88 in
Removed: PST TLT PWR
Aperture(%dia.)
-1.07 wave
Points 30408
Removed: PST TLT PWR
PV
0.023
wave
RMS
0.003
wave
Pts.
30408
Power
1.071
General Optics, Inc.
3b
Measurement Controls
Part Number: LIGO TEST MASS - SIDE 1
Serial Number: SP ETM 03A
Min Mod Pct: 3
Inspector: S. RILES
Intens Avgs: 4
Intf Scale Factor: 0.5
Phase Avgs: 4
Refractive Index: 1.500000
AGC: On
Phase Res: Normal
Time: Wed Jun 4 08:55:32 1997
AGC Mode: Normal Reflectivity
Instrument: Mark IVxp Id 0 SN 4532 SB 0
Phase Avg Pause: Off
Wavelength-In: 6328.0 A
Wavelength-Out: 6328.0 A
Subtract Sys Err: Off
Sys Err File: SysErr.dat
Discon Action: Ignore
Discon Filter: 45
Light Level: 17
Filter Trim: Off
Filter Window Size: 3

J-6108 LIGO TEST MASS SPETM 03A S-1

Processed
RMS 0.49 angstroms
P-V 3.39
1024 points

4 Jun 1997 10:15:20

GENERAL OPTICS, INC.
(805) 529-3324
554 FLINN AVENUE
MOORPARK, CA. 93021

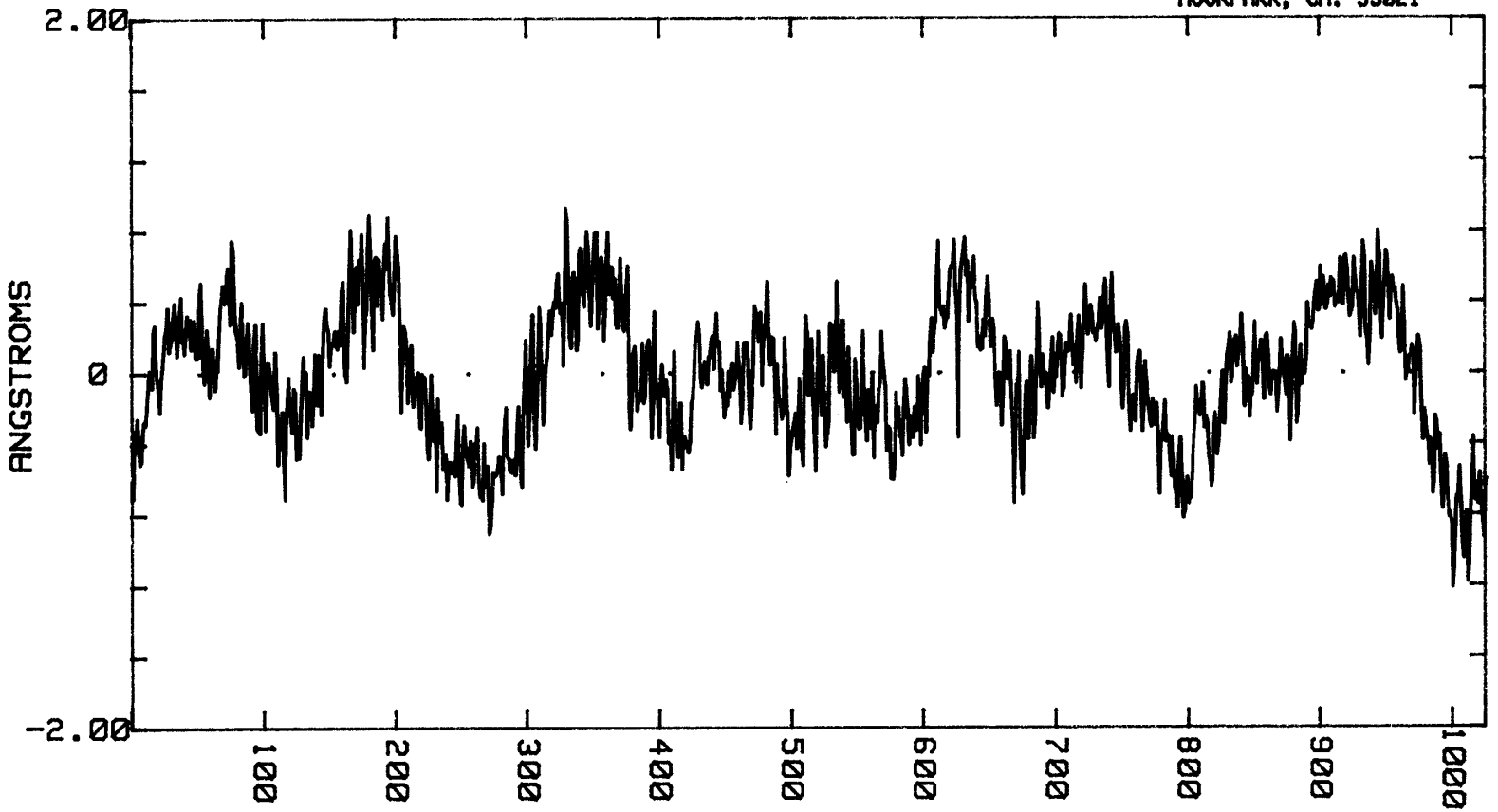


J-6108 LIGO TEST MASS SPETM 03A S-2

Processed
RMS 0.38 angstroms
P-V 2.15
1024 points

27 Mar 1997 10:42:30

GENERAL OPTICS, INC.
(805) 529-3324
554 FLINN AVENUE
MOORPARK, CA. 93021



GENERAL OPTICS, INC.

554 FLINN AVE.
MOORPARK, CA 93021
PHONE: (805) 529-3324.• FAX: (805) 529-4298

INVOICE NUMBER	24692
INVOICE DATE	6/11/97

CUSTOMER ORDER NO.	DATE ORDERED	DATE DUE	SHIP VIA	DATE SHIPPED
PC203459	10/18/96		Fed-X SOS Prepay & Bill	6/11/97

F.O.B.	TERMS OF PAYMENT	TAXABLE	BUYER'S NAME
Moorpark	Net 30 Days	No	Tina Lowenthal (818) 395-2758

SOLD TO
CALTECH
Accounts Payable 201-6
Pasadena, CA 91125

SHIP TO
National Institute of Standards & Technology
Route 124 and Clopper Road
Gaithersburg, MD 20899

Attn: Chris Evans

ITEM	ITEM DESCRIPTION	QUANTITY ORDERED	QUANTITY PREVIOUS SHIPMENT	QUANTITY BACK-ORDERED	QUANTITY THIS SHIPMENT	UNIT PRICE	AMOUNT
1	Polish LIGO Test Mass Optics per Specification E950104-A-D and per Drawing D960791-A-D. Note: All work to be performed on a best-effort basis. Serial Numbers: SPETM01A SPETM02A SPETM03A SPETM04A SPETM05A	8	0	3	5	7500.00	37,500.00
2	Non-recurring set-up charge	1 Lot	0	0	1 Lot	5000.00 Lot	5000.00

These items were visually inspected by me at General Optics, and were drop shipped to NIST per my instructions.

GariLynn Billingsley, CALTECH 6-11-97 Date

SUBTOTAL	42,500.00
SALES TAX	0.00
SHIPPING CHARGES	0.00
TOTAL	**$42,500.00**

A late charge of 1% per month will be charged on past due balances.

We are an Equal Opportunity Employer M/F

We hereby certify these goods were produced in compliance with all applicable requirements of Sections 6, 7 and 12 of the Fair Labor Standards Act, as amended and of regulations and orders of the United States Department of Labor issued under Section 14 thereof

J-6108, 6118

WHITE / Original • YELLOW / Duplicate • PINK / Accounting • GOLDENROD / Accounting • GREEN / Packing Slip

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 : 29 June 98
- Customer Name, Purchase Order No. : Caltech Ligo
- Customer Part Number & Revision : Li60-E980068-00-D
- Part Description : SPETM02, SPETM03
- REO Job No. : OpT0583I-025 Run No.: HR: OX765, HR@1064nm AR: OX769, AR@1064nm
- Qty. Shipped/Lot No. : 1 ea SPETM02
  1 ea SPETM03

X Test data (included)

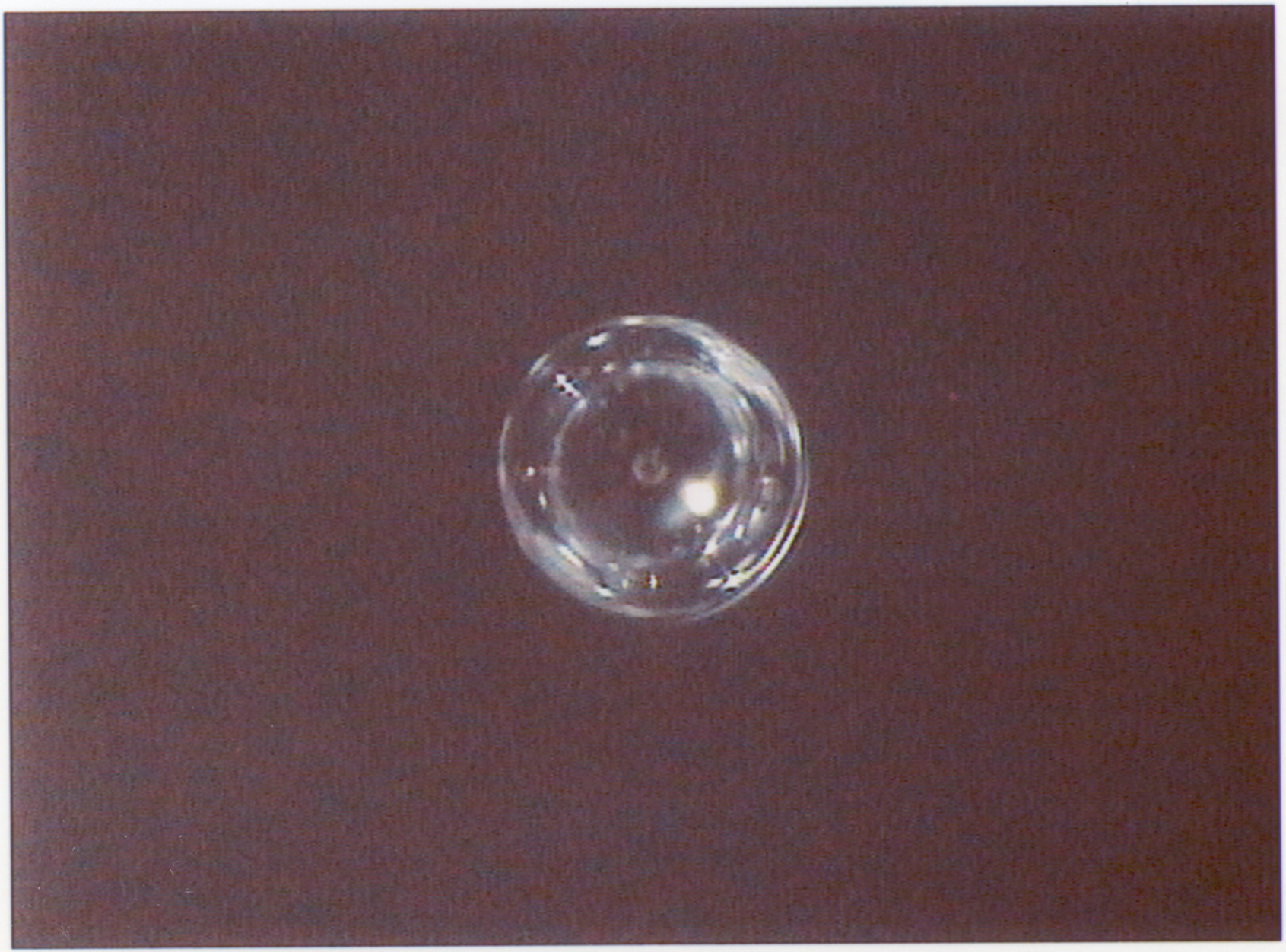
Comment:

Certified by: _____, 6.29.98
Quality Assurance

Verified by: _____, 29 June 98
Engr/Tech

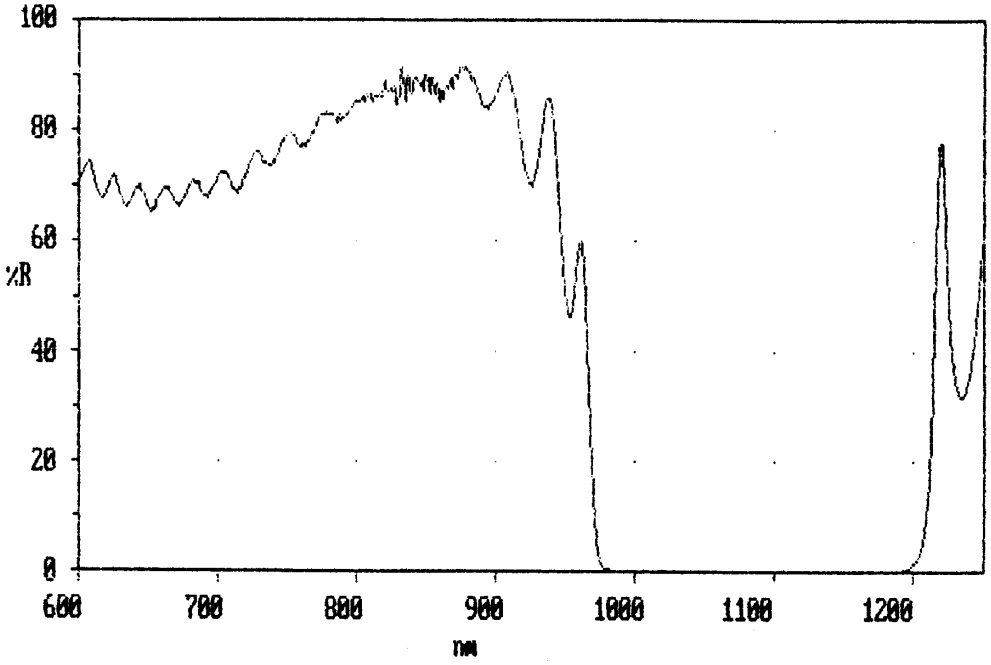
NOTE
Certificate must accompany the package to be shipped or attached to the outside of the same box to which the "Packing Slip" envelope is attached.

SPETMØ3-A



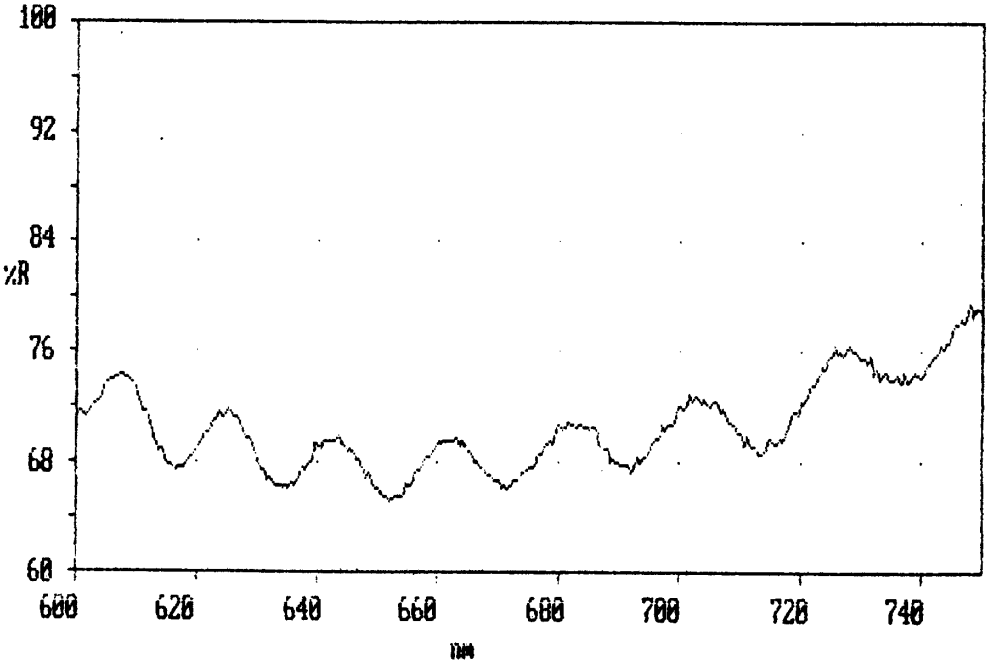
Inclusion: 0.485 mm diameter

X: user002: 1250.0 - 600.0 nm; pts 1301; int 0.50; ord -0.325 - 92.225 %R
Inf: #0X765, HR @ 1064nm, baked, SPETM02, 03

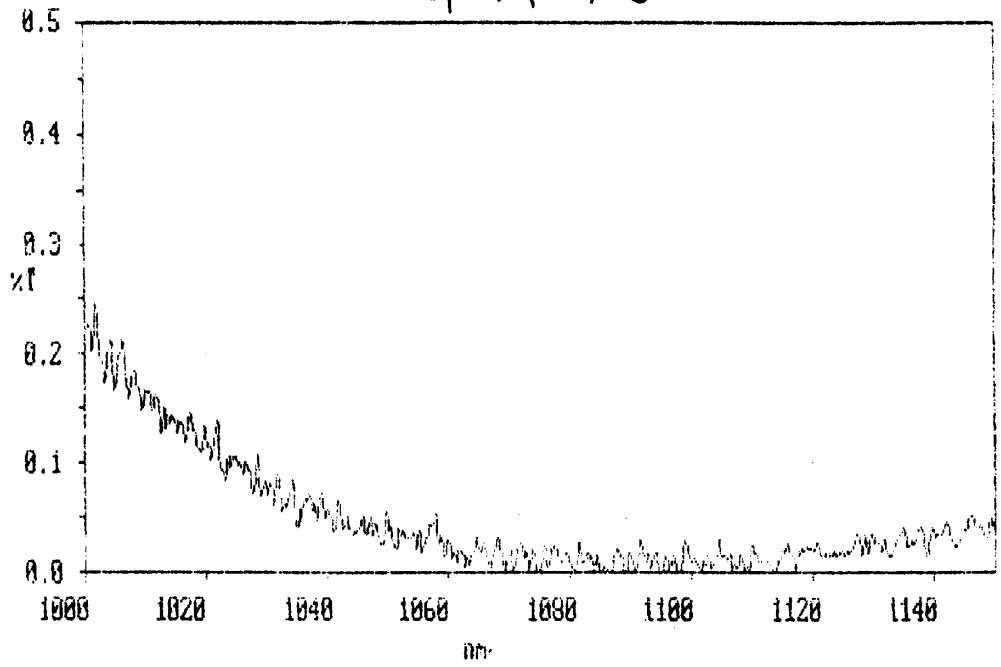


$\lambda_c = 1077nm$

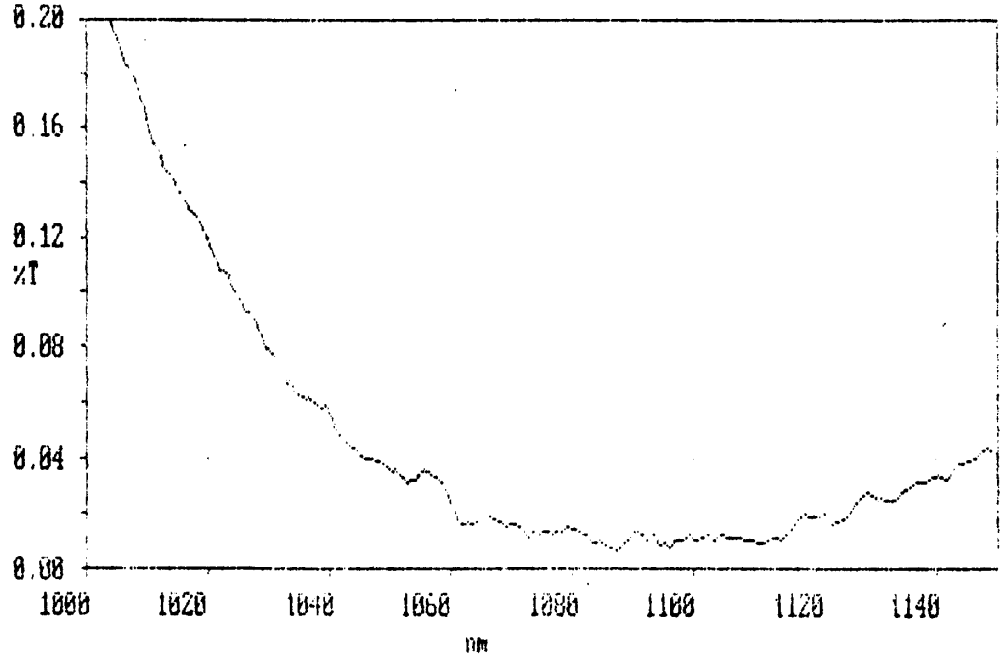
X: user002: 1250.0 - 600.0 nm; pts 1301; int 0.50; ord -0.325 - 92.225 %R
Inf: #0X765, HR @ 1064nm, baked, SPETM02, 03



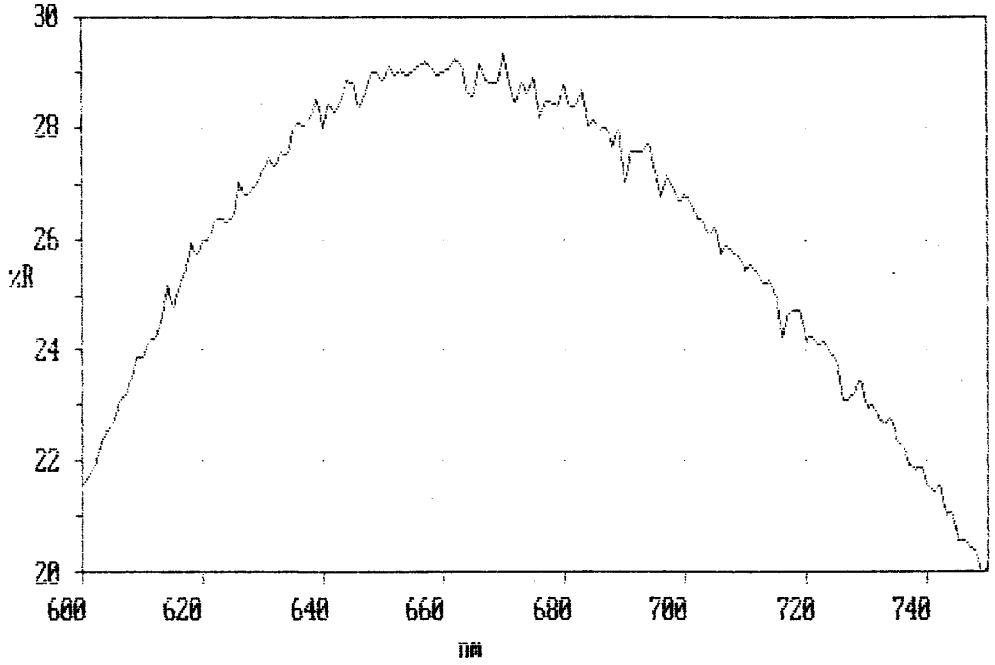
X: user001: 1150.0 - 1000.0 nm; pts 751; int 0.20; ord -0.007 - 0.2489 %T
Inf: #0X769 AR @ 1064nm after bake Spect02,03



X: user001: 1150.0 - 1000.0 nm; pts 751; int 0.20; ord 0.0070 - 0.2249 %T
Inf: #0X769 AR @ 1064nm after bake



X: user001; 750.0 - 600.0 nm; pts 151; int 1.00; ord 19.956 - 29.357 %R
Inf: #0X769, AR @1064nm, after bake, for SPETM 02,03



Research Electro-Optics, Inc.

PAGE NO: 2
INVOICE NO: [illegible]
INVOICE DATE: [illegible]

INVOICE

CUSTOMER ID: [illegible]
CUSTOMER PO: [illegible]
BILL TO:

CALIFORNIA INST. OF TECHNOLOGY
[illegible]
[illegible]
PASADENA, CA [illegible]

[illegible]
[illegible]
SHIP TO:

CALIFORNIA INST. OF TECHNOLOGY
[illegible]
[illegible]
PASADENA, CA [illegible]

TERMS: CASH #1: DISC: SHIPPED: 06/29/1998
CASH #2: DISC: SHIP VIA: FED-EX P1
NET DUE DATE: 072998 F.O.B.: FACTORY
SHIPMENT NO: [illegible] REF:
YOUR CUSTOMER REP IS: JM
PRO NO:

QTY. ORDERED	QTY. SHIPPED	QTY. B.O.	ITEM NUMBER	UNIT PRICE	EXT. PRICE

THIS ORDER IS A CHANGE ORDER TO REC[redacted]

PER QUOTE OPQ 2403 & OPQ[redacted]

REFERENCE: CALTECH LIGO [illegible]/LIGO-C98[redacted]
LIGO-C950494 [illegible]

Technical Contact:
Helena Armandula Tel: [illegible]-395-2070
Mail Code [illegible]

Contractual Representative:
Irena Petrac Tel: [illegible]-395-2975
Mail Code [illegible]

Items #001 thru #014 [illegible] POR PC1625[redacted]

Items #015 thru #039 [illegible] POR PC1625[redacted]
Per REO quote #OPQ-2537, [illegible] Item #067 on[redacted]
acknowledgement.

SPETM[illegible] 03

[illegible] 0 [illegible]980068
[illegible] LIST MAS[illegible] [illegible]

[redacted]

CONTINUED ON NEXT PAGE

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

Rec'd complete 06-30-98

[signature]

PACKING LIST