

FM04

LIGO-T990146-00-D

BLANK

T970013 FE 05
FM04

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 / QD 10624801
Glass Mfg. Part No.: 24622E FE-05 F855306
Manufacturer's Boule No.: 24622E
Date Received at Caltech: 1-08-97

- 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" 256.72 mm
 - Inspection of material thickness. Thickness 4.2900" 108.99 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: Steven Olson Date Inspected: 1-10-97

Reviewed and/or accepted by:

Cognizant Engineer: Janice Bellamy Date: 2-25-97
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.) _____

SKETCHES:

DISPOSITIONS: _____

CORNING INCORPORATED
CORNING
CORNING, NEW YORK

SHIPPING ORDER

PACKING LIST

ORD. DATE [PP207573] 08/20/96

CNG ORD NO. [GD106248]

OLD TO CALIFORNIA INSTITUTE OF TECHNOLOGY
ACCOUNTS PAYABLE P/O # 201-6
1200 E CALIF BLVD
PASADENA, CA 91125

13717
CA 056 04

SAME AS "SOLD TO" UNLESS OTHERWISE SPECIFIED
SHIP TO CALIFORNIA INSTITUTE OF TECHNOLOGY
ATTN: MR. LOWELL JONES
391 S HOLLISTON
PASADENA, CA 91102

13717
CA 056 02

LES CODE [110 050]

DISCOUNT FACTOR []

DESIRED SHIP DATE [12/20/96]

PPED O.B. [CANTON, NY] DATE ENTERED [08/28/96]
UPI FOR ORIG PPD FR INVOICED

WE EXPECT TO SHIP [12/20/96]
11/20/96

DATE SHIPPED	INVOICE #
DATE SHIPPED	
ROUTING	52637
BEST WAY	UPS R
CAR INITIAL AND NUMBER	
THIS SHIPMENT	
PARTIAL	COMPLETE
	X
DATE ISSUED	DATE TO SHIP
12/18/96	12/18/96

WHSE. LOC.	PRODUCT CODE	DESCRIPTION	QUANTITY	
			UNITS	CASES
01	855306 7990 0000	DISC. F S.O.A. 10.079"D X 4.252"T, BLANK TOLERANCES: +.040"/-.000" BOTH DIMS FOLDING MIRROR, END TEST MASSES CLEAR APERTURE = 9.252" 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 # L100-6960097-A-D DWG#: L100-D960794	3	1 PC
			BW	
003	855308 7990 0000	DISC. F S.O.A. WITNESS SAMPLE, .984" X .984" CYLINDRICAL YOUR PRODUCT IDENT - WITNESS SAMPLES INCREASED SAMPLES FOR ITEMS PRICE IS INCLUDED IN ITEM 001	3	1 PC
			BW	
		12-19-96 Rec'd 3 cartons in good Condition. <i>Steven Gibson</i>		
		FE 05		

CORNING

334 County Route 16
Canton, New York 13617-9703

Canton Plant . . .



... WHERE QUALITY MIRRORS PRIDE

CERTIFICATE OF COMPLIANCE

Customer: <u>California Institute of Technology</u>	Item: <u>001</u>
Customer Order No.: <u>PP207573</u>	Glass: <u>7980 Grade 0A</u>
Corning Order No.: <u>QD106248</u>	Quantity Shipped: <u>3</u>
Code No.: <u>855306</u>	Date Shipped: <u>1/8/97</u>

Registration Mark for & Serial # per LIGO
 Drawing # D960794-A-D
 Birefringence ≤ 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 24801

Corning Part Number: F 855306

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

Boule Number: _____

Quantity Affected: 11

Deviation Description: SBT PIC5 to be used in lieu of individual pics of each piece
(attach backup information as deemed necessary)

Car. Lynn Billingsley OK YTB
2-24-97
Customer Contact (print)

Randy W. Bond 12/12/96
Authorizing Signature Date

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

Billing Status

- Bill Now
- Bill in 30 Days
- Other _____

Deviation Number:

<small>(sequential number)</small> <small>(year)</small>

cc: Shipping Clerk
Customer Service

FE Ø5

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"	4.290 / 4.2905 / 4.2905 / 4.290		QA
Registration Mark	Per LIGO - D960794	Top center of optic	See Attached Cert.		M
Serial & Boule #	Per LIGO -D960794	Boule and Serial No.	24622ECT-FE05		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 < <u>1.0</u> x 10E-6	9.73E x 10 ⁻⁸		M
Homogeneity - outside		Peak To Valley < <u>2.5</u> x 10E-6	5.98E x 10 ⁻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 <u>A</u>	Inspection Report		M
Absorption		< 20 ppm / cm @ λ = 1.06 μm	See attached Cert.		M

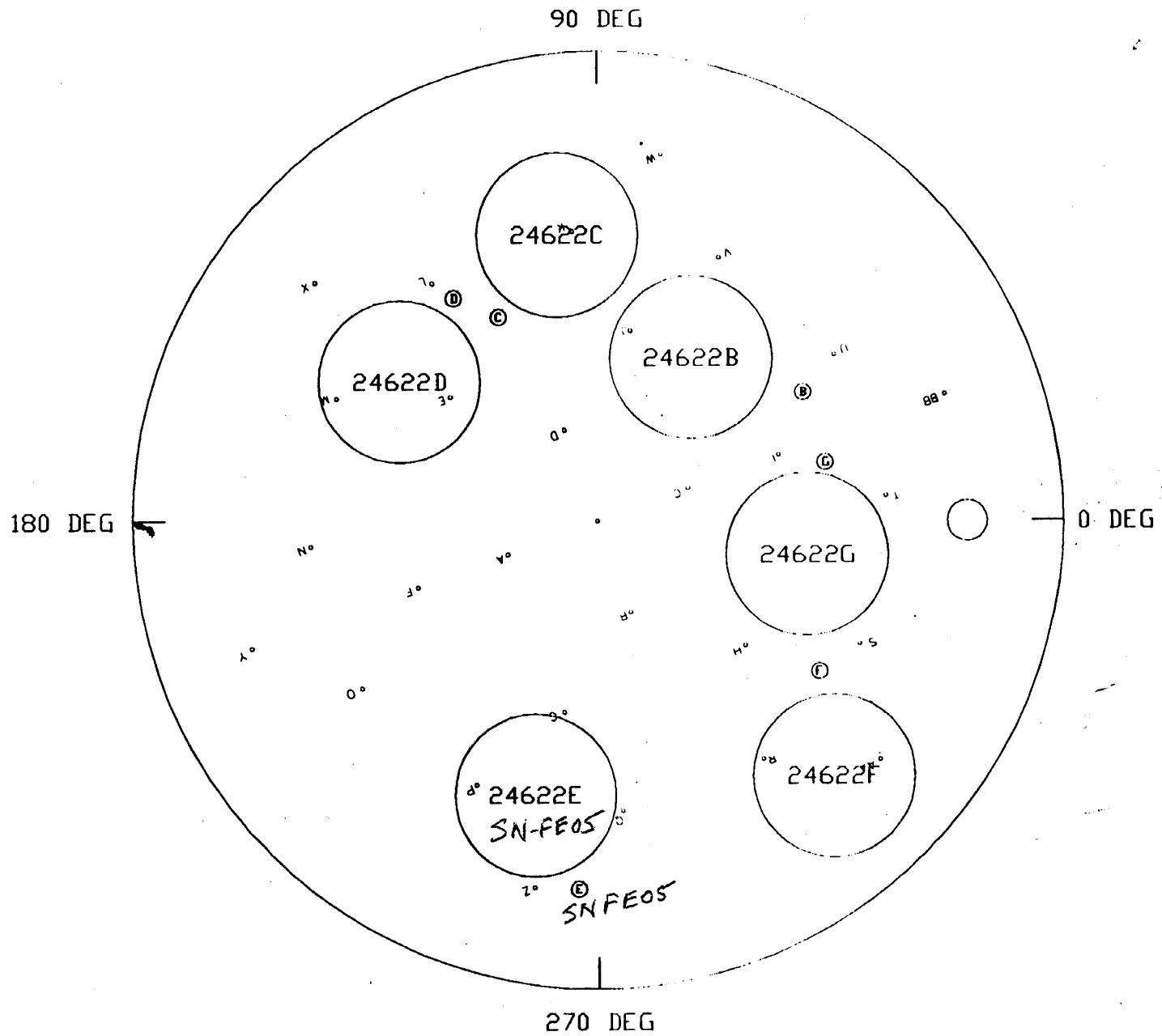
Comments:

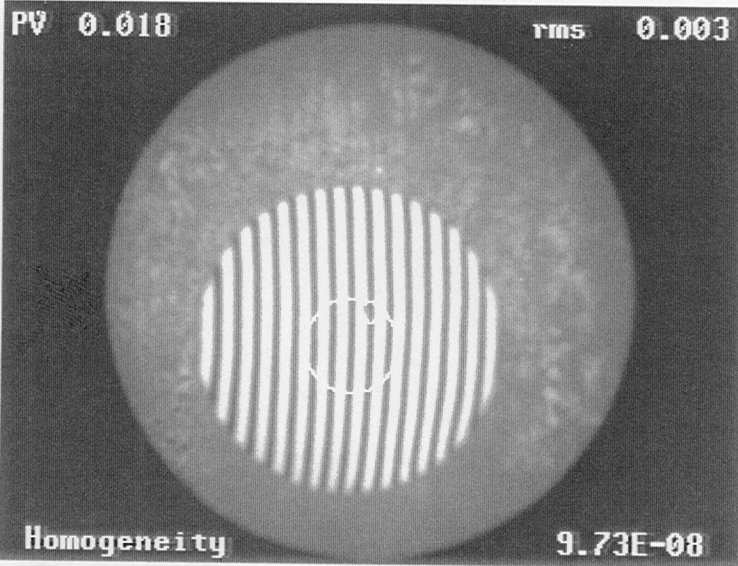
Inspected by: _____

Gail Andrews

Date: 1-7-97

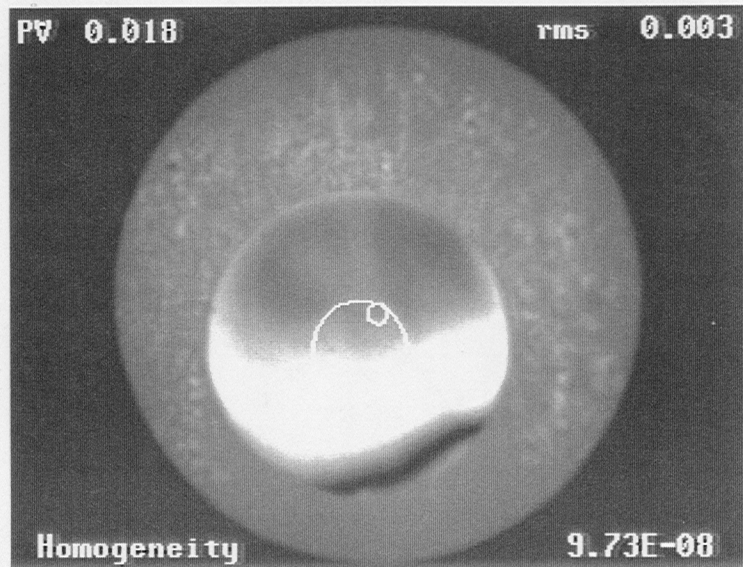
24622E - FE05





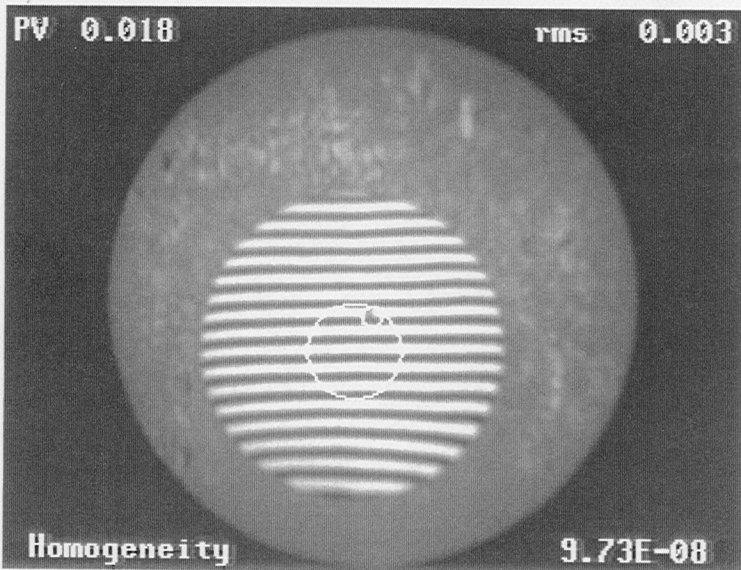
24622E

SN-FE05



24622E

FE05



24622E

FE05

Lg Aperture

PV 0.018 wave

rms 0.003 wave

Power 0.000 wave

Homogeneity 9.73E-08

Points 1270

AstMag (Z) 0.014 wave

zygo Spike

Remove Spikes: Off (xRMS): 3.00

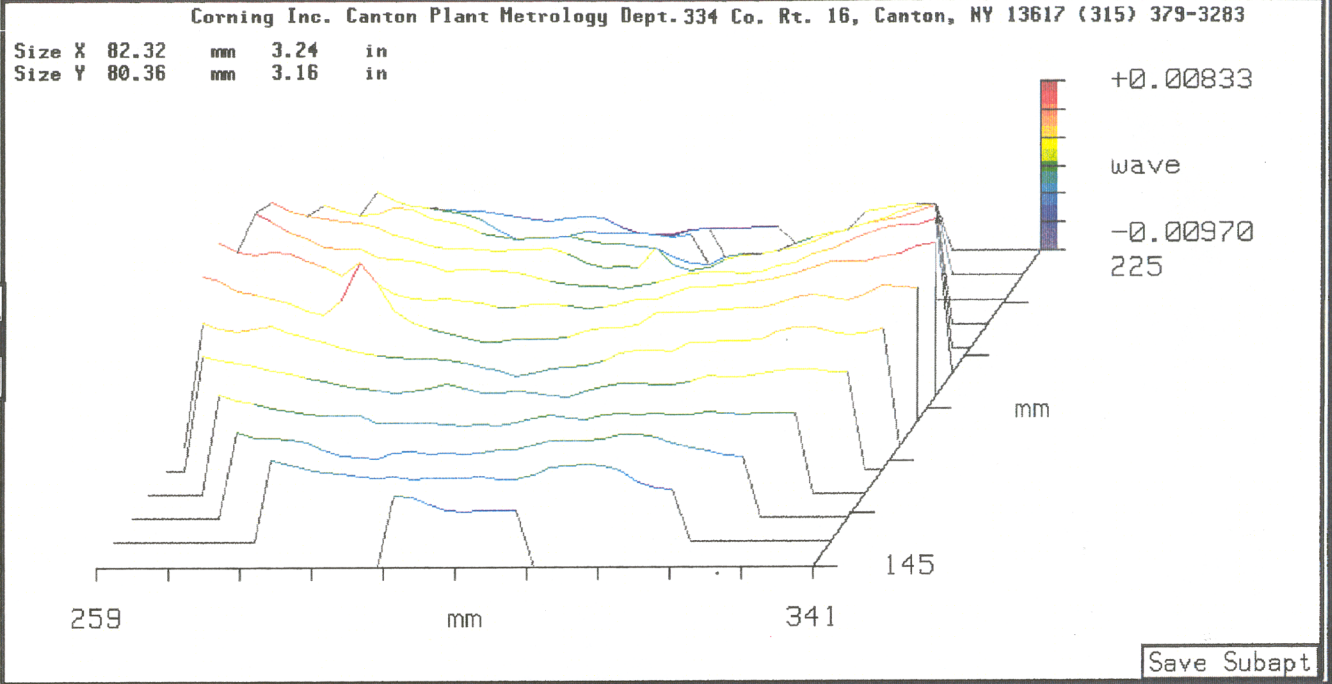
Data Fill: Off Data Fill Max: 25

Removed:

PST TLT PWR

PST TLT PWR AST CMA SA3

Zern Terms: 36



Zernike Coefficients from 1269 data points

Order: 10th Terms: 36 rms: 0.001

0.000	-0.001	-0.001	0.000						
0.007	0.000	-0.001	-0.001	0.000					
0.000	0.002	-0.001	0.001	0.000	0.000	0.000			
0.001	0.000	0.000	0.000	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	0.000	0.000

Measure Mask Data Save Data DBSAVE

Analyze Calibrate Load Data

zygo File Data

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

Sys Err File: r121396.8a2 Phase Res: High

Part Thickness: 4.62 in Scale: 0.500

Boule #: 24622 AGC: Off

Suffix: E Light Level: 110

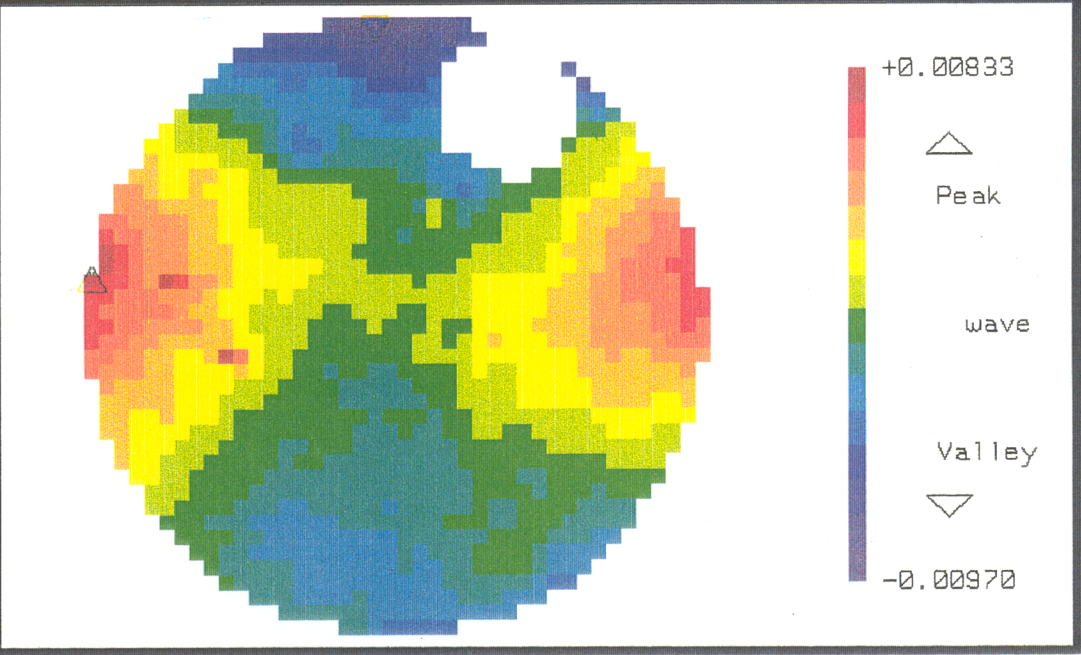
Comment:

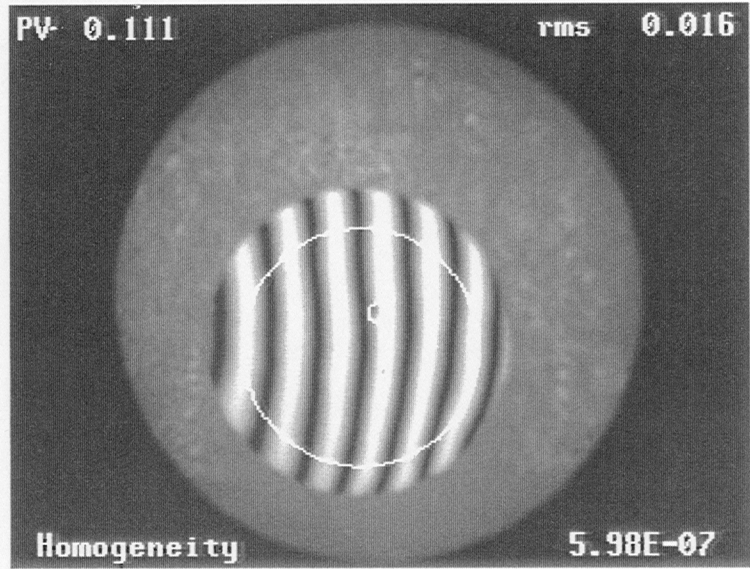
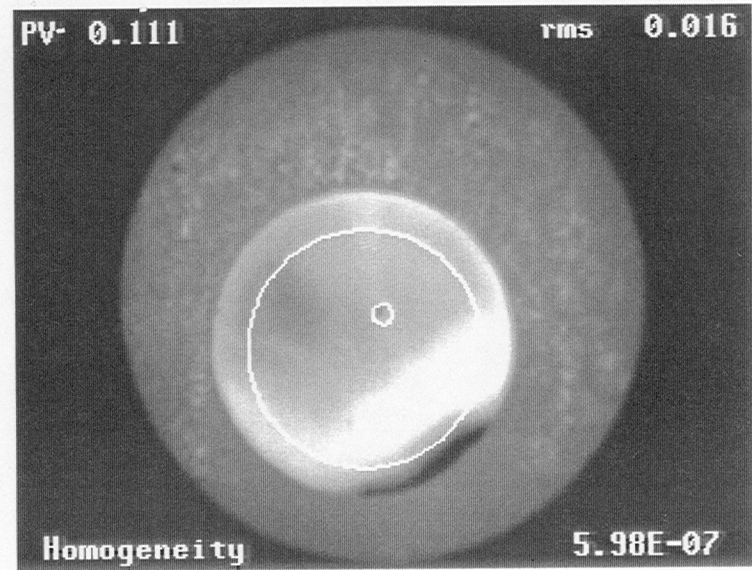
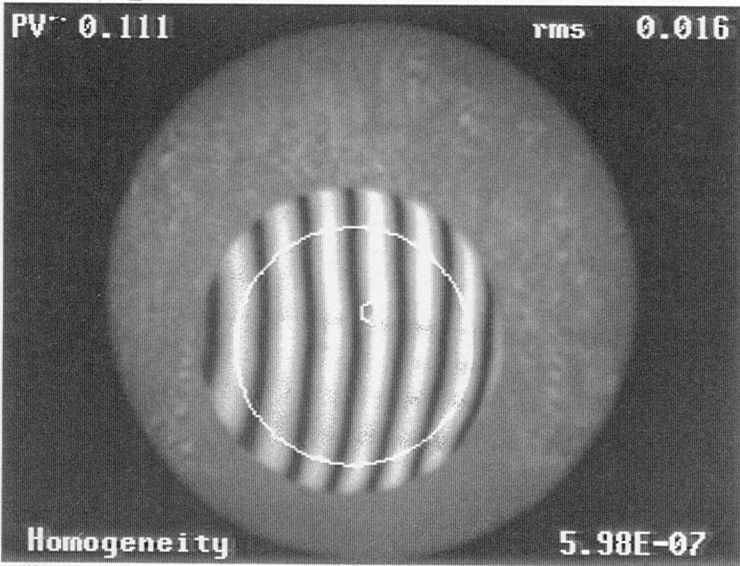
CAL TECH SN-FE05

Data File: 24622E2.ct Phase Avgs: 6

Camera Res: 1.9600 mm Intens Avgs: 6

Time: Fri Jan 03 22:15:59 1997



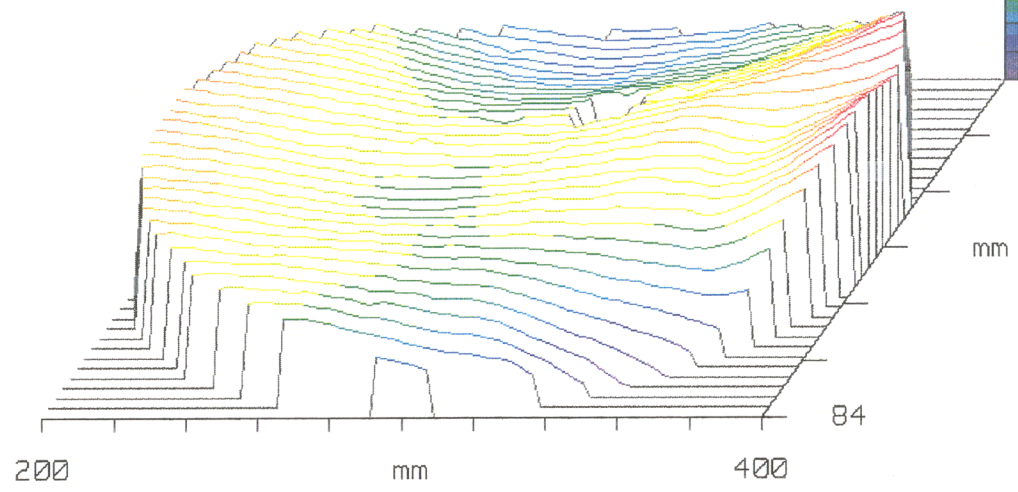


Lg Aperture
PV 0.111 wave
rms 0.016 wave
Power 0.000 wave
Homogeneity 5.98E-07
Points 8171
AstMag (Z) 0.068 wave

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

+0.04922
wave
-0.06151
286



Save Subapt

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	-0.001	0.000	0.000																
0.032	0.012	-0.004	0.006	0.001															
0.013	0.011	0.000	0.002	0.005	0.003	0.000													
0.004	-0.004	0.003	-0.005	0.001	-0.001	-0.001	-0.002	-0.001											
0.001	-0.004	0.003	-0.001	0.000	0.001	-0.001	0.001	-0.001											

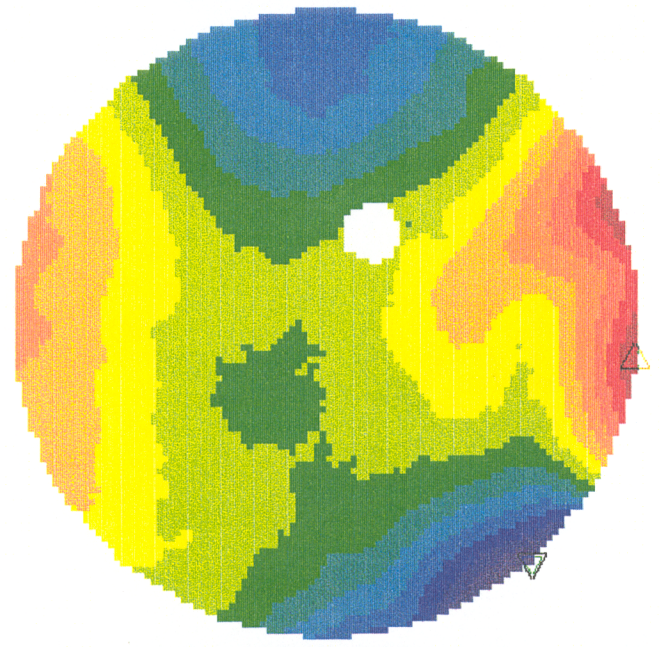
Measure Mask Data Save Data DBSAVE
Analyze Calibrate Load Data

zygo File Data

Subtract Sys Err: On Min Mod (%): 1
Sys Err File: r121396.8a2 Phase Res: High
Part Thickness: 4.62 in Scale: 0.500
Boule #: 24622 AGC: Off
Suffix: E Light Level: 110

Comment:
CARL TECH SN-FE05

Data File: 24622E1.ct Phase Avgs: 6
Camera Res: 1.9600 mm Intens Avgs: 6
Time: Fri Jan 03 22:15:59 1997



+0.04922
Peak
wave
Valley
-0.06151

pertains to serial numbers
FE01 - FE09 - JB

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

CC:
Petrae
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 31", 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.

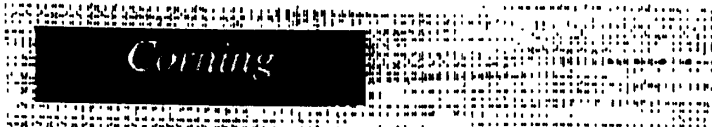
Hopefully this document addresses the current issues between CalTech -LIGO project and Corning-Canton. If there are any additional issues that need to be addressed by Corning, please do not hesitate to contact me.

Thank you for your patience in this matter.

Sincerely,

Randy VanBrocklin
Applications Engineer

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

The logo features the word "Corning" in a serif font, centered within a dark rectangular box. This box is set against a background of a dense, light-colored dot matrix pattern. A horizontal dotted line extends from the right side of the box across the page.

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

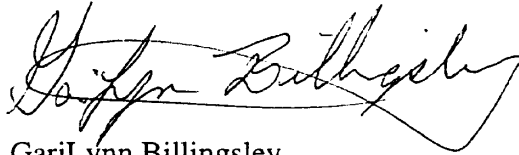
Some clarification of preferences and some discrepancies came to light during examination of the data packages for the first 9 blanks delivered to LIGO. While none of these compromise the integrity of the blanks, they can make for a confusing or misleading data package. Please let us know how you expect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

A handwritten signature in cursive script, appearing to read "GariLynn Billingsley". The signature is written in black ink and is positioned above the printed name.

GariLynn Billingsley
Technical Representative

MIRROR



Research Electro-Optics Inc.

CERTIFICATE OF CONFORMANCE

Section 3.14/REO QC Manual, Q-001, Doc. No. V:QA:REO 014, Rev."B", 09/13/96

Certificate of Conformance from: Research Electro-Optics (REO) Inc.
1855 South 57th. Court
Boulder, Colorado 80301
(303) 938-1960, Fax (303) 447-3279

Research *Electro-Optics* (REO), Inc. hereby certifies that the items listed below have been inspected and tested to the extent necessary to conform with all the requirements of the noted Purchase Order, drawing, and applicable specification(s). Inspection and test data are on file at our facility and will be furnished to customer upon request.

- Date of shipment : 5/29/98
- Customer Name, Purchase Order No. : Ligo; pot# PC162519/CONOS
- Customer Part Number & Revision : LI60E980065
- Part Description : FMO3, FMO4; HR @ 1064nm @ 45°
- REO Job No. : OPT05831-019 Run No.: OX745, OX747
- Qty. Shipped/Lot No. : 2 pcs

Test data (included)

Comment:

Certified by: [Signature], 5/29/98
Quality Assurance

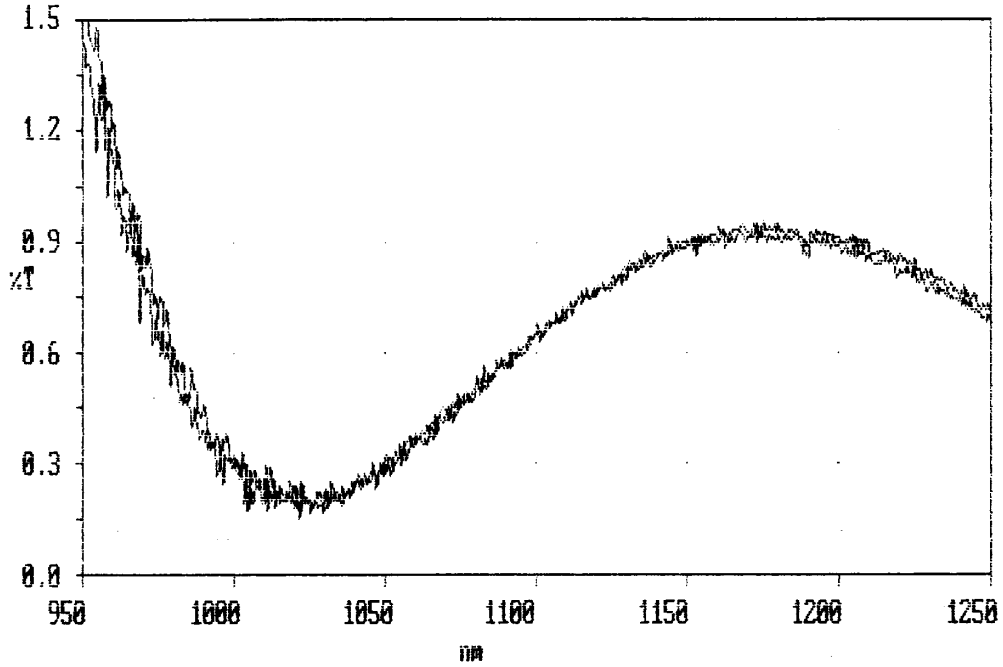
Verified by: [Signature], 5/29/98
Eng/Tech

NOTE

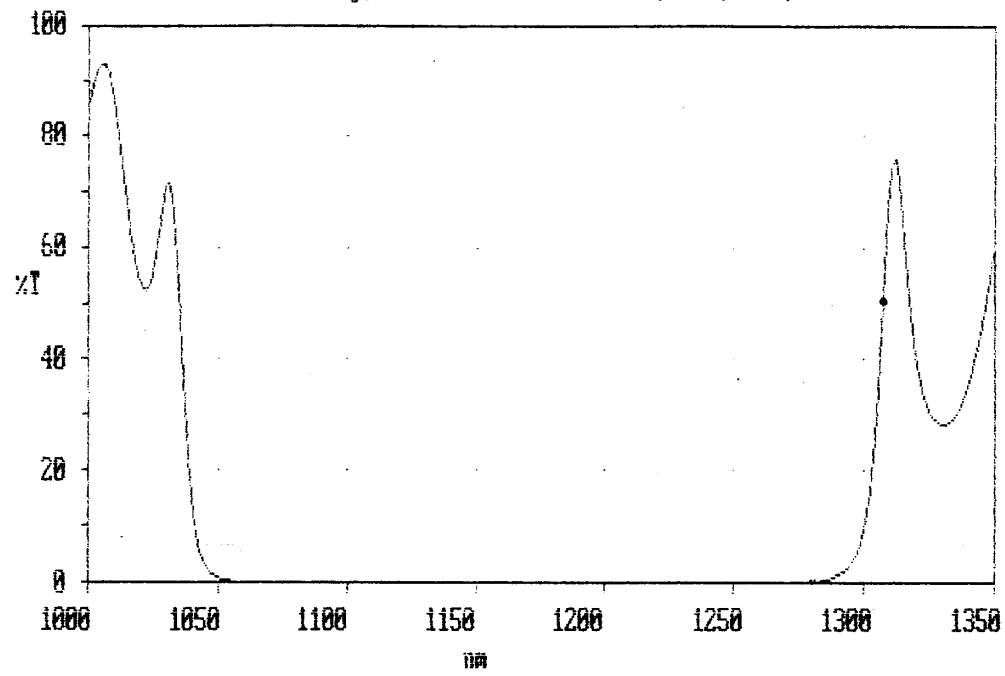
Certificate must accompany the package to be shipped or attached to the outside of the same box to which the "Packing Slip" envelope is attached.

Y: user002; 1250.0 - 950.0 nm; pts 601; int 0.50; ord 0.1447 - 1.6840 %T
Inf: ox747 AR01064nm @ 45deg for FM03,04

FM03; FM04

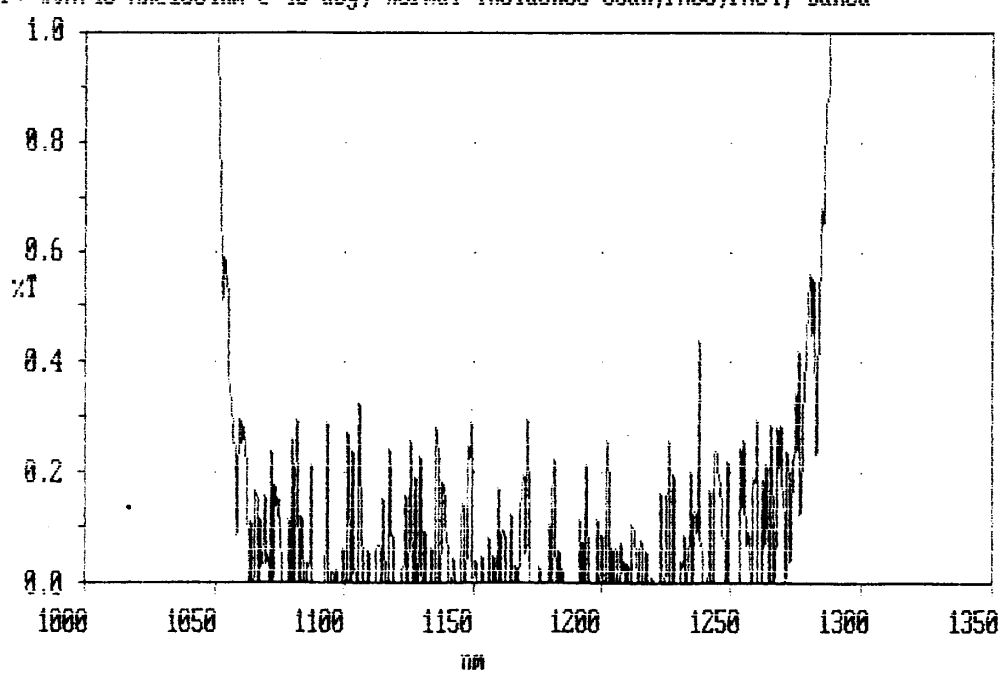


X: USER002; 1350.0 - 1000.0 nm; pts 1751; int 0.20; ord -0.415 - 93.295 %T
Inf: #0X745 HR01064nm @ 45 deg, normal incidence scan,FM03,FM04, baked

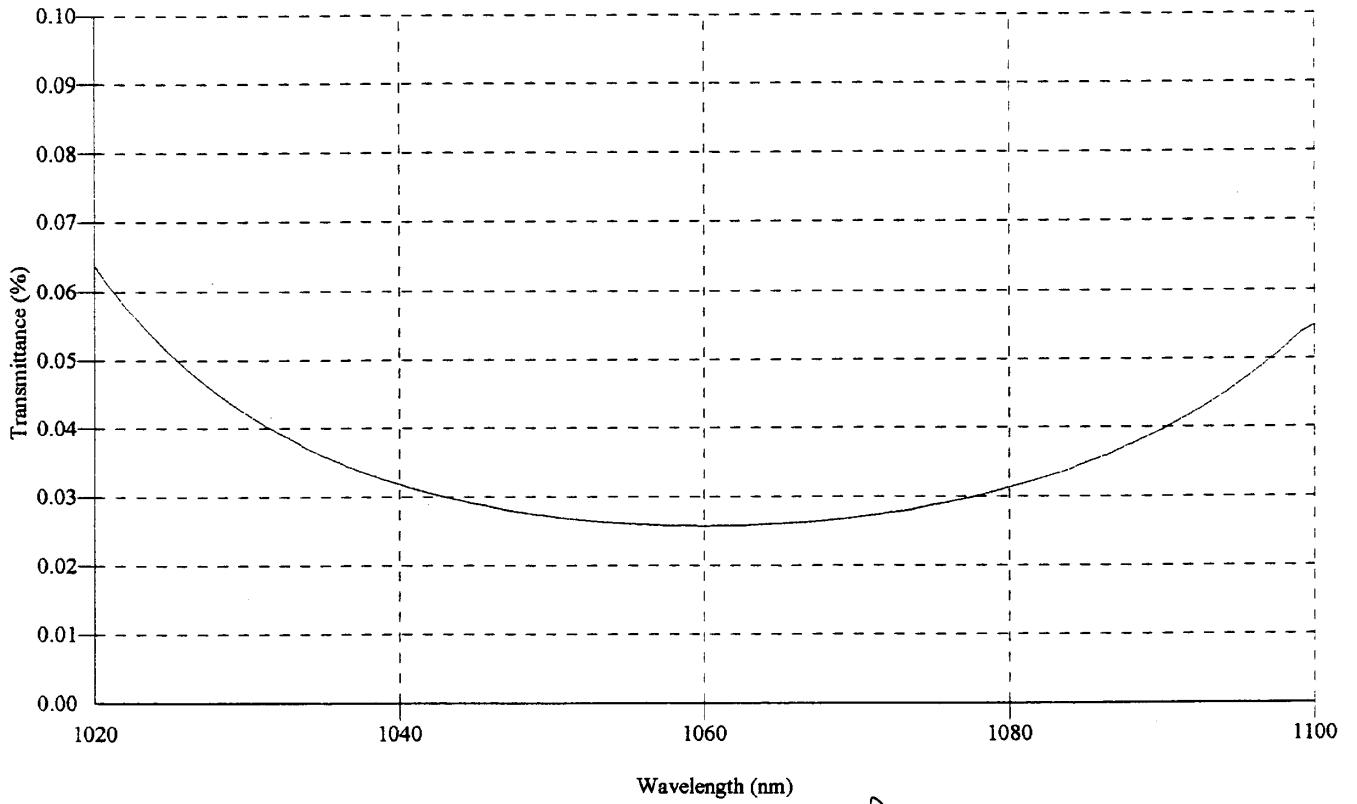


$\lambda_h = 1307.5$
 $\lambda_c = 1035.2$
 $\lambda_c = 1156 \text{ nm}$

X: USER002; 1350.0 - 1000.0 nm; pts 1751; int 0.20; ord -0.415 - 93.295 %T
Inf: #0X745 HR01064nm @ 45 deg, normal incidence scan,FM03,FM04, baked

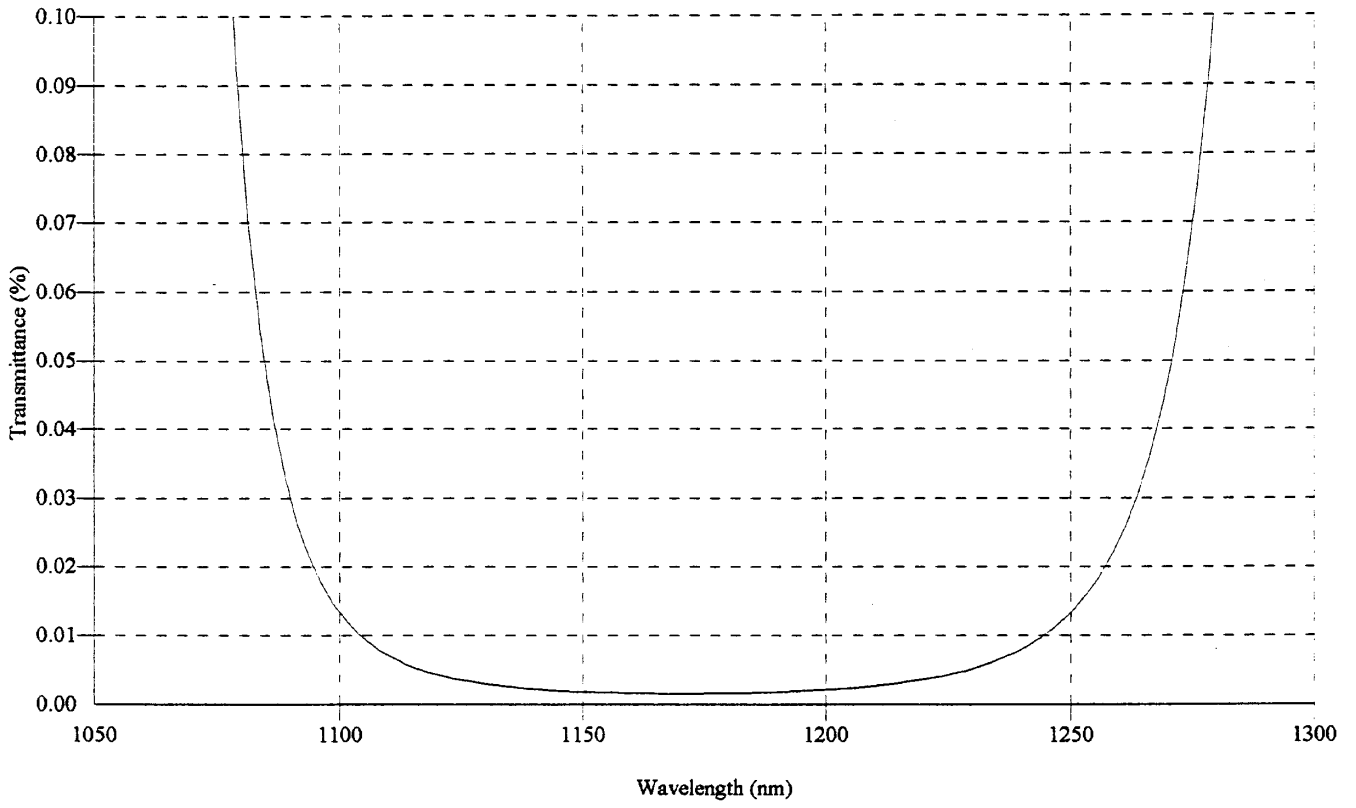


LHR500PP: Transmittance



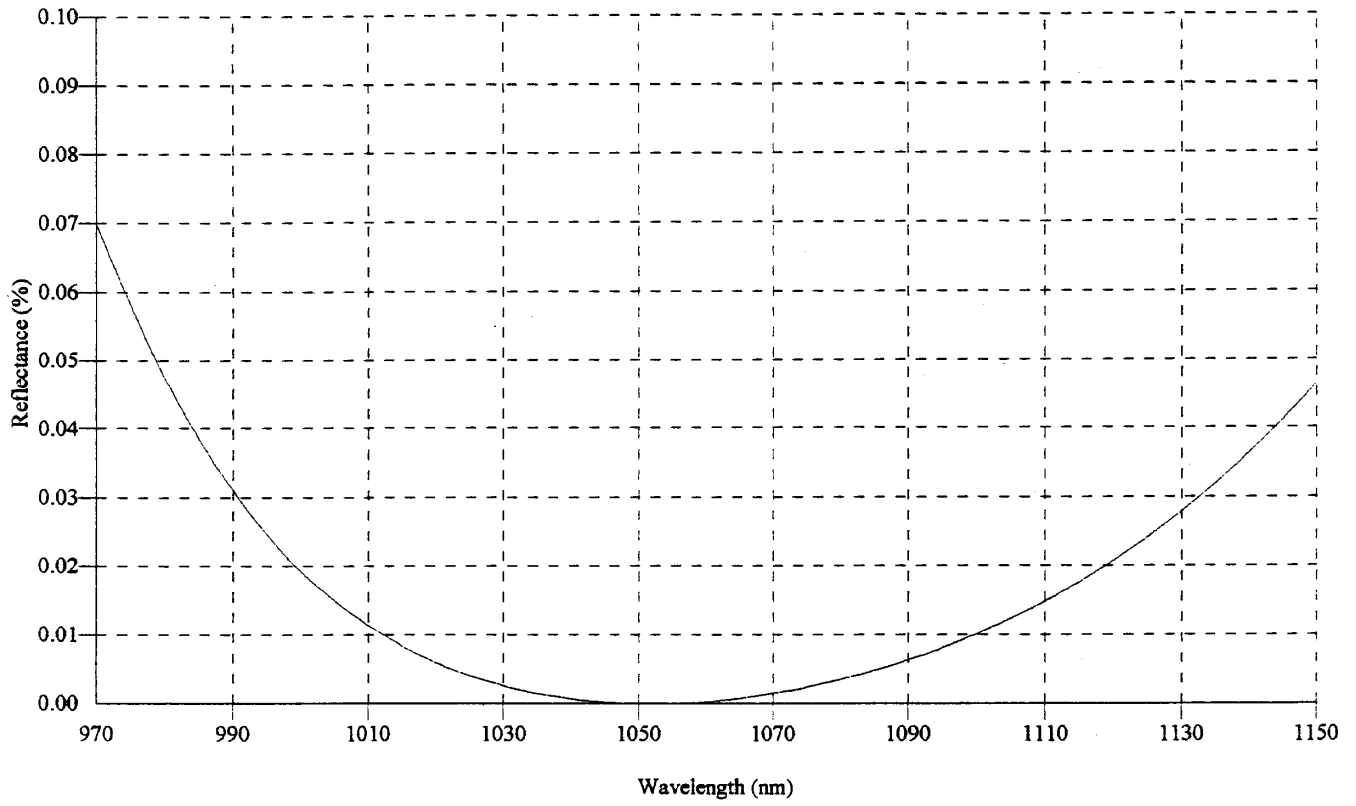
Performance @ 45°

LHR500PP: Transmittance



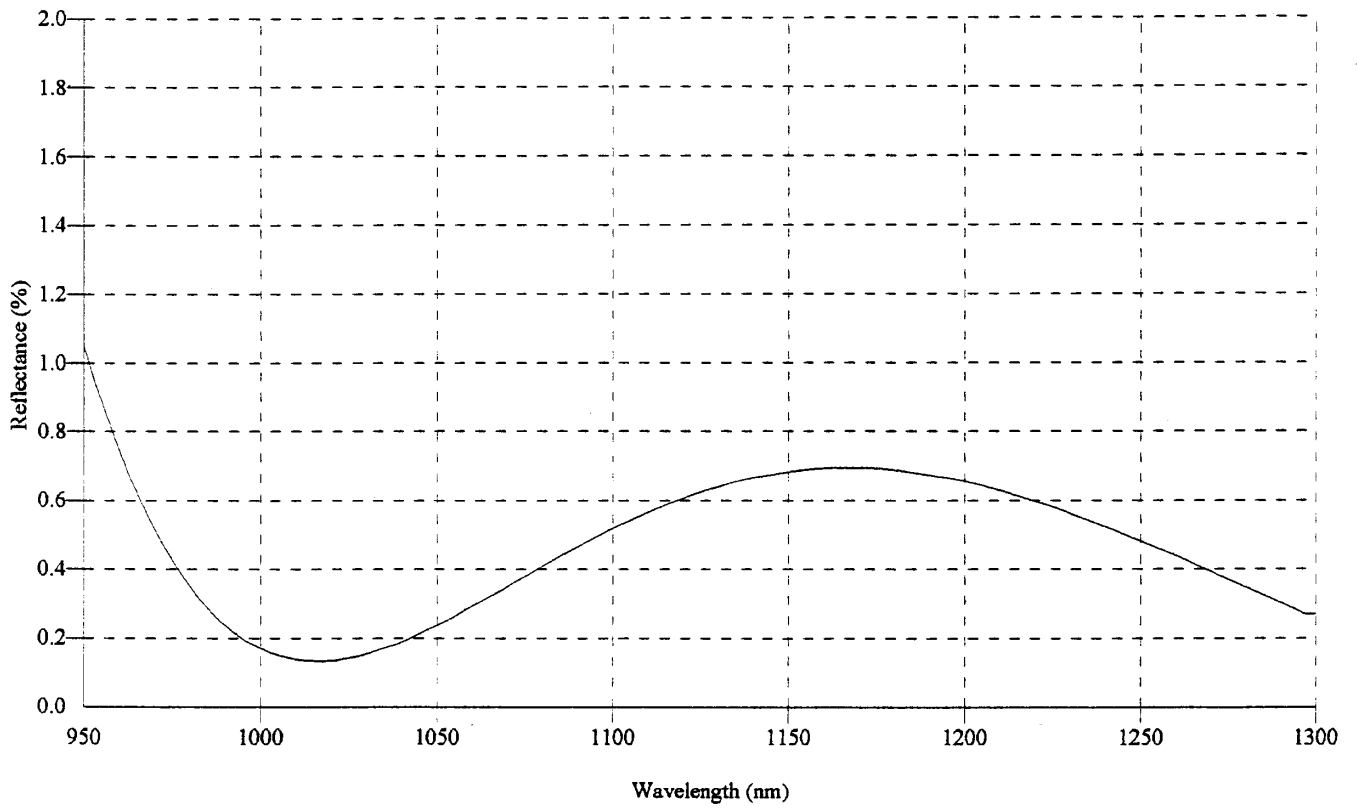
Performance @ 0°

LAR45PA: Reflectance



Performance @ 45°

LAR45PA: Reflectance



Performance @ 0°



**Research
Electro-Optics, Inc.**

ORDER NO: 810051
 ORDER DATE: 06/03/1999

INVOICE

ORDER NO: 810051
 ORDER DATE: 06/03/1999

YOUR ORDER NO: PC162513-110051
 OUR ORDER NO: 06105831-0004
 SHIP TO:

CALIFORNIA INST. OF TECHNOLOGY
 51-33 EAST BRIDGE LAB, L100
 PASADENA, CA 91125

CALIFORNIA INST. OF TECHNOLOGY
 51-33 EAST BRIDGE LAB, L100
 ATTN: MELINDA SHIMMURA, L100
 PASADENA, CA 91125

TERMS: CASH #1: 0151
 CASH #2: 0151
 NET DUE DATE: 070398

SHIP TO: PASADENA, CA 91125
 FROM: FACTORY
 SHIPMENT NO: 005146 REF:
 PRO NO:

YOUR CUSTOMER REP IS: JH

QTY	QTY	QTY	ITEM	UNIT PRICE	EXTD PRICE
ORDERED	SHIPPED	STOCK	NUMBER		

PER QUOTE: 060-2403

REFERENCE: CALIFORNIA LIBRARY 8-600/L160-1
 0-0950492-1

Technical Support:
 Helena Aranda Tel: 26-395-2070
 Mail Code 18-05

Contractual Representative:
 Irene Petrac Tel: 26-395-2975
 Mail Code 18-05

Item #001 thru #014 on 100 PC162513-110051

Item #015 thru #039 on 100 PC162513-110051
 Per REQ quote 0020-2537 on Item #027 on

Approved:

2 FOLDING MIRROR COATED

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