FM03

LIGO-T990145-00-D

BLANK

T970012 FE04
FM03

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.: PP 207573
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.: ~~24622C~~ FE04 F855306
Manufacturer's Boule No.: 24622 C
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: _____

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

- ☑ Inspection of material diameter. Diameter 10.110 in. 256.84mm
- ☑ Inspection of material thickness. Thickness 4.2905 in 109.00mm
- ☐ ~~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 see attached

☑ 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: _____

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.)

3½" floppy for 246220 not in packet.

SKETCHES:

DISPOSITIONS: Sent memo to Corning advising them of the missing data floppy; date 01-31-97.

To: Randy VanBrocklin, Brian Bush

From: Garilynn Billingsley

Copy enclosed.

36-R

CORNING INCORPORATED
CORNING
CORNING, NEW YORK

SHIPPING ORDER
PACKING LIST

ORD. DATE: PP207573 — 08/20/96
CNG ORD NO.: GD1[illegible]6248

SOLD TO:
CALIFORNIA INSTITUTE OF TECHNO — 13717
ACCOUNTS PAYABLE M/S 301-8 — CA 074 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	INVOICE NO.

DATE SHIPPED
ROUTING: 5263 ~~BEST WAY~~ UPS RC
CAR INITIAL AND NUMBER

THIS SHIPMENT: PARTIAL	COMPLETE	PREPAID
		X

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

SALES ORDER: 110 050
DISCOUNT FACTOR:
DESIRED SHIP DATE: 12/20/96
SHIPPED O.B.: CANTON, NY — DFI FOB ORIG PPD FRT INVOICED
DATE ENTERED: 08/28/96
WE EXPECT TO SHIP: ~~12/20/96~~ 11/20/96

ITEM	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 FOLDING MIRROR, END TEST MASSES CLEAR APERATURE = 9.252" PLUS [illegible] 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 # LI90-E960097-A-D SUB# LI90-D960794	3	PC
003		855308 7980 0000	DISC, F S,OA,WITNESS SAMPLE, .984" X .984" CYLINDRICAL YOUR PRODUCT IDENT -->> WITNESS SAMPLES WITNESS SAMPLES FOR ITEMS 1 PRICE IS INCLUDED IN ITEM 001	3	PC

BW

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

FE04

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: 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 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 2.24.97

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 Ø4
(sequential number) - *(year)*

Q704 rev. A

cc: Shipping Clerk
Customer Service

DATA SHEET - CAL TECH LIGO MIRROR BLANKS

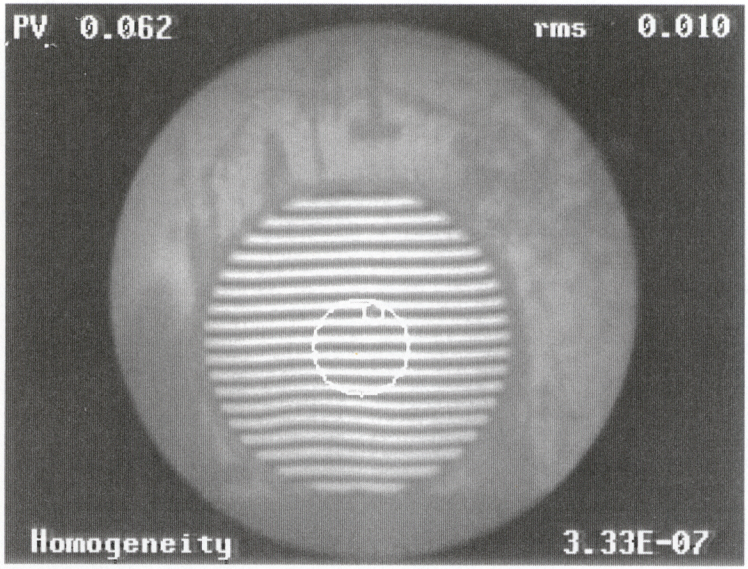
Cal Tech Purchase Order Number: PP207573

Cal Tech Drawing Number: LIGO-D960794

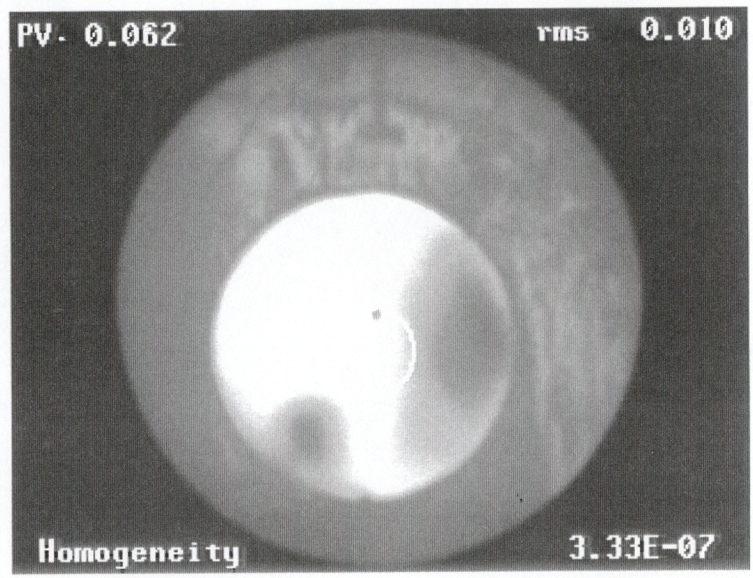
Attribute	Specification #	Requirement	Actual	Stamp	
Diameter	Per LIGO - D960097-A-D	10.079", -0.0"/+0.4"	10.108 / 10.108		QA
Thickness	Per LIGO - D960097-A-D	4.252",- 0.0" / + 0.4"	4.2905 / 4.2905 / 4.2905 / 4.2905		QA
Registration Mark	Per LIGO - D960794	Top center of optic	See Attached Cert.		M
Serial & Boule #	Per LIGO -D960794	Boule and Serial No.	246220[illegible]04		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	3.33×10^{-7}		M
Homogeneity - outside		Peak To Valley < 2.5 x10E-6	1.14×10^{-6}		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:

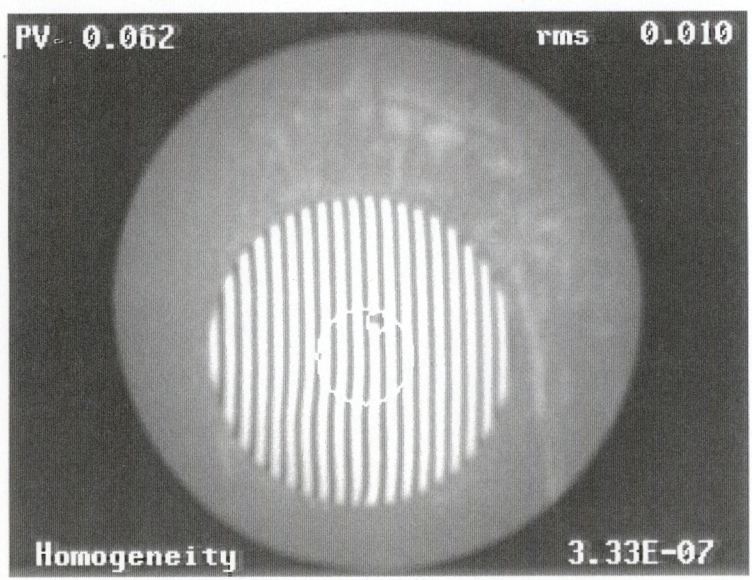
Inspected by: Gail Andrews Date: 1-7-97



24622c FE04



24622c FE04



24622c FE04

zygo

Homogeneity

Lg Aperture

PV 0.062 wave

rms 0.010 wave

Power -0.007 wave

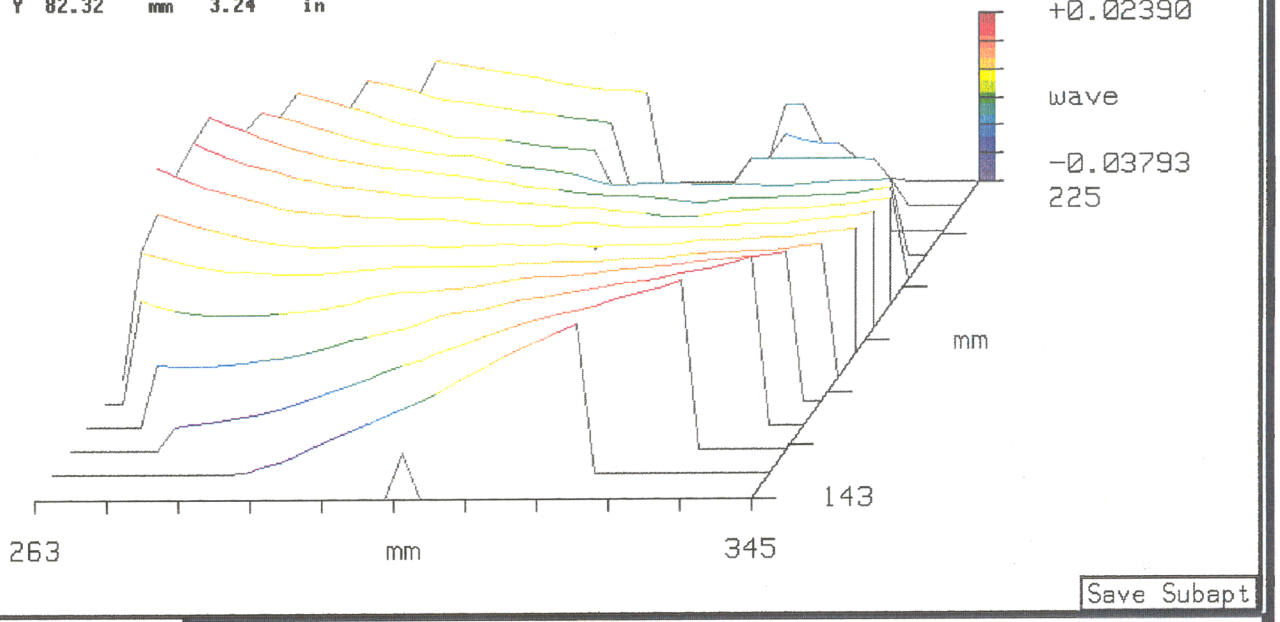
Homogeneity 3.33E-07

Points 1292

AstMag (Z) 0.048 wave

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

zygo Spike

Remove Spikes: Off (xRMS): 3.00

Data Fill: Off Data Fill Max: 25

Removed:

PST TLT PWR

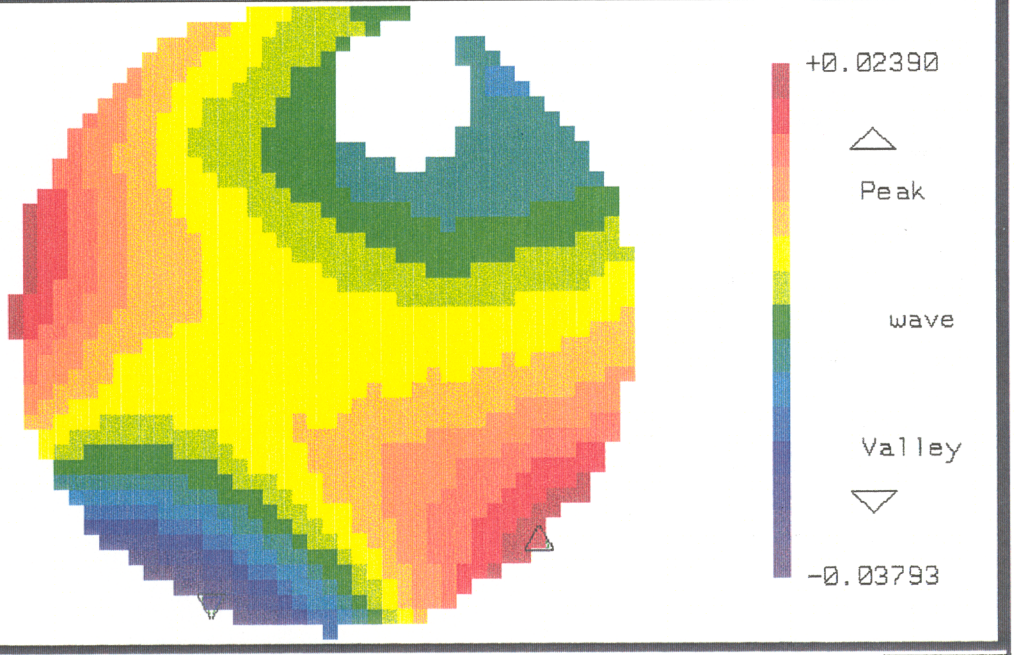
PST TLT PWR AST CMA SA3

Zern Terms: 36

Zernike Coefficients from 1291 data points

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

-0.052	0.018	0.054	-0.004					
0.012	-0.020	0.002	0.008	0.001				
-0.011	-0.004	0.001	0.000	-0.001	-0.001	0.000		
0.001	0.003	0.000	-0.001	0.000	-0.001	0.000	-0.001	0.000
0.001	0.001	-0.001	0.000	0.001	0.001	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: 4.619 in

Boule #: 24622

Suffix: C

Comment:

CAL TECH SN FE04

Data File: 24622C2.ct

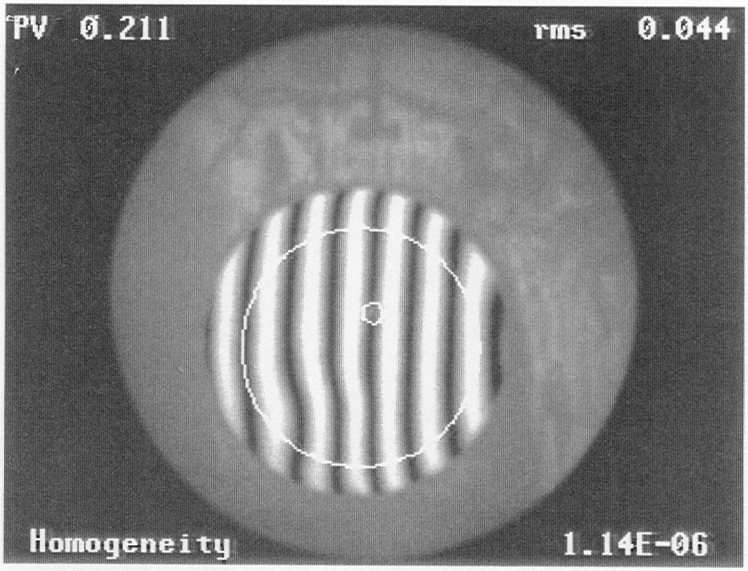
Camera Res: 1.9600 mm

Reset

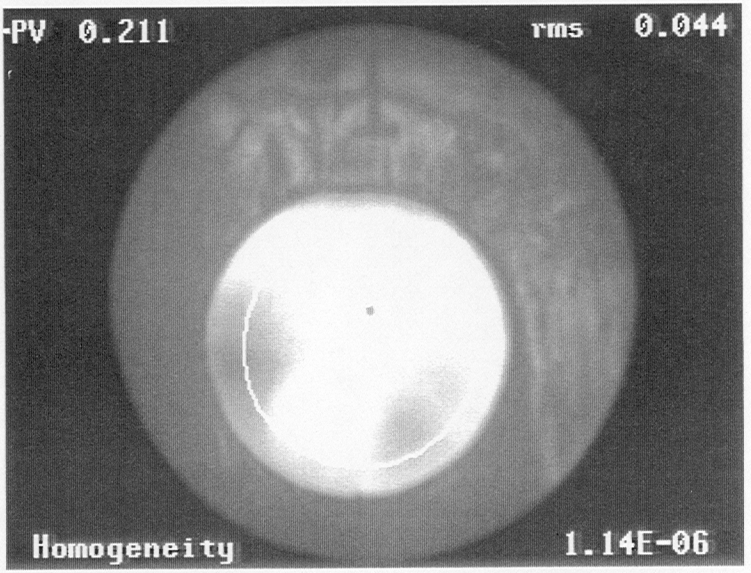
Time: Sun Jan 05 14:00:16 1997

SlopeMag TiltXY Filter AutoSeq Manipulate Metroscript FileData

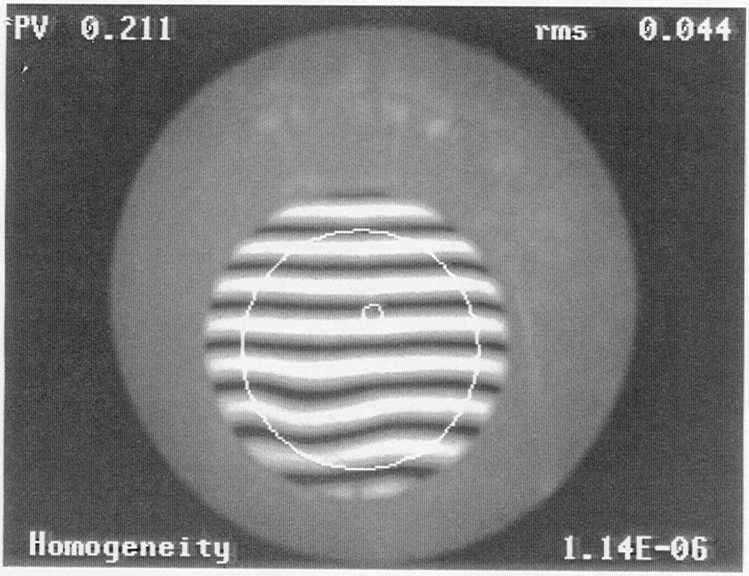
Profile VideoMon SlopeY SPC Meas Controls FileCopy Report ZernGen



24622c FE04



24622c FE04



24622 SN FE04

zygo — Homogeneity

Lg Aperture

PV 0.211 wave
rms 0.044 wave
Power -0.003 wave
Homogeneity 1.14E-06
Points 8203
AstMag (Z) 0.170 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 8202 data points
Order: 10th Terms: 36 rms: 0.004

-0.060 0.059 -0.001 -0.002
0.054 -0.066 -0.024 -0.018 0.002
-0.051 -0.004 -0.009 0.025 -0.002 -0.008 -0.003
0.005 0.028 0.024 0.002 0.000 -0.001 0.003 0.008 0.000
0.015 -0.012 -0.005 -0.015 -0.005 -0.006 0.001 -0.004 -0.002

Measure | Mask Data | Save Data | DBSAVE
Analyze | Calibrate | Load Data

Subtract Sys Err: On
Sys Err File: r121396.8a2
Part Thickness: 4.619 in

Boule #: 24622
Suffix: C

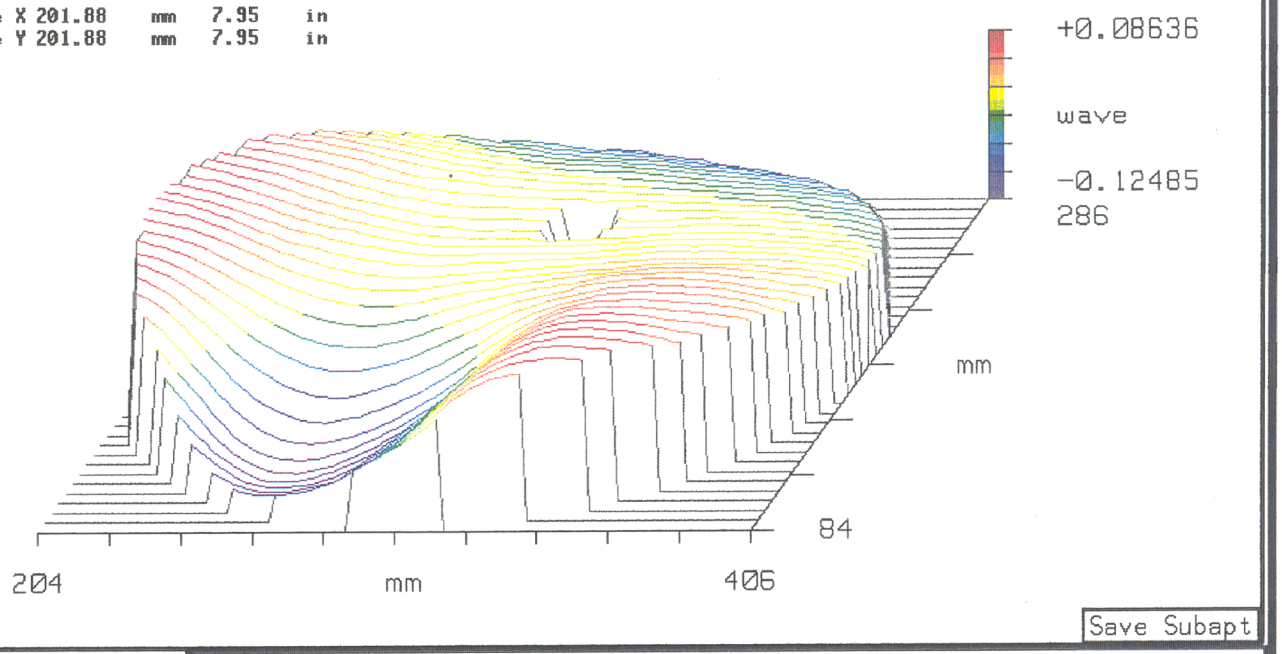
Comment:
CAL TECH SN-FE04

Data File: 24622C1.ca
Camera Res: 1.9600 mm
Time: Sun Jan 05 13:51:08 1997

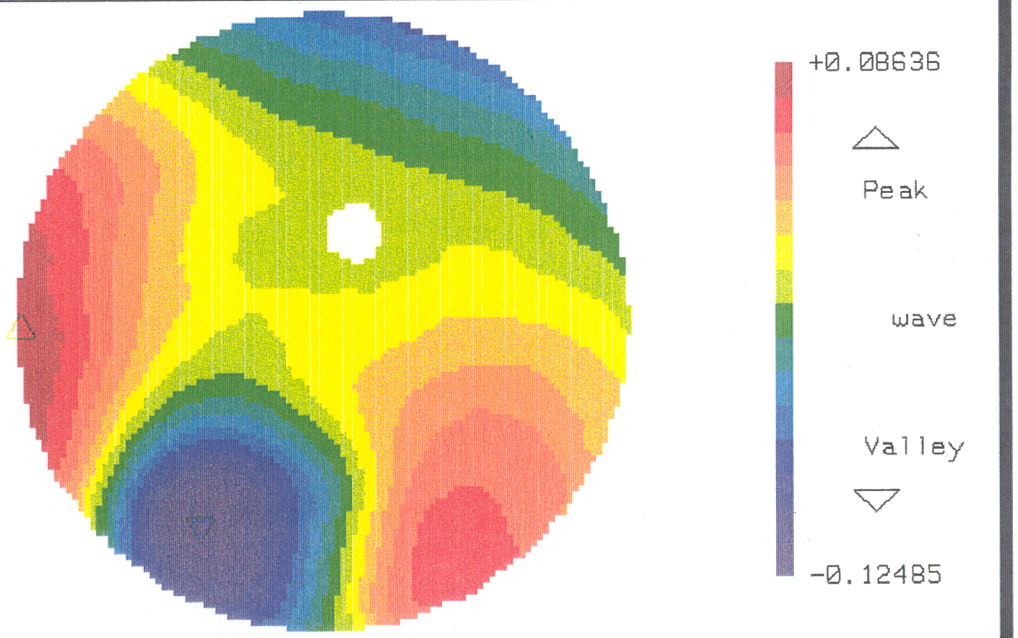
Reset

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

Size X 201.88 mm 7.95 in
Size Y 201.88 mm 7.95 in



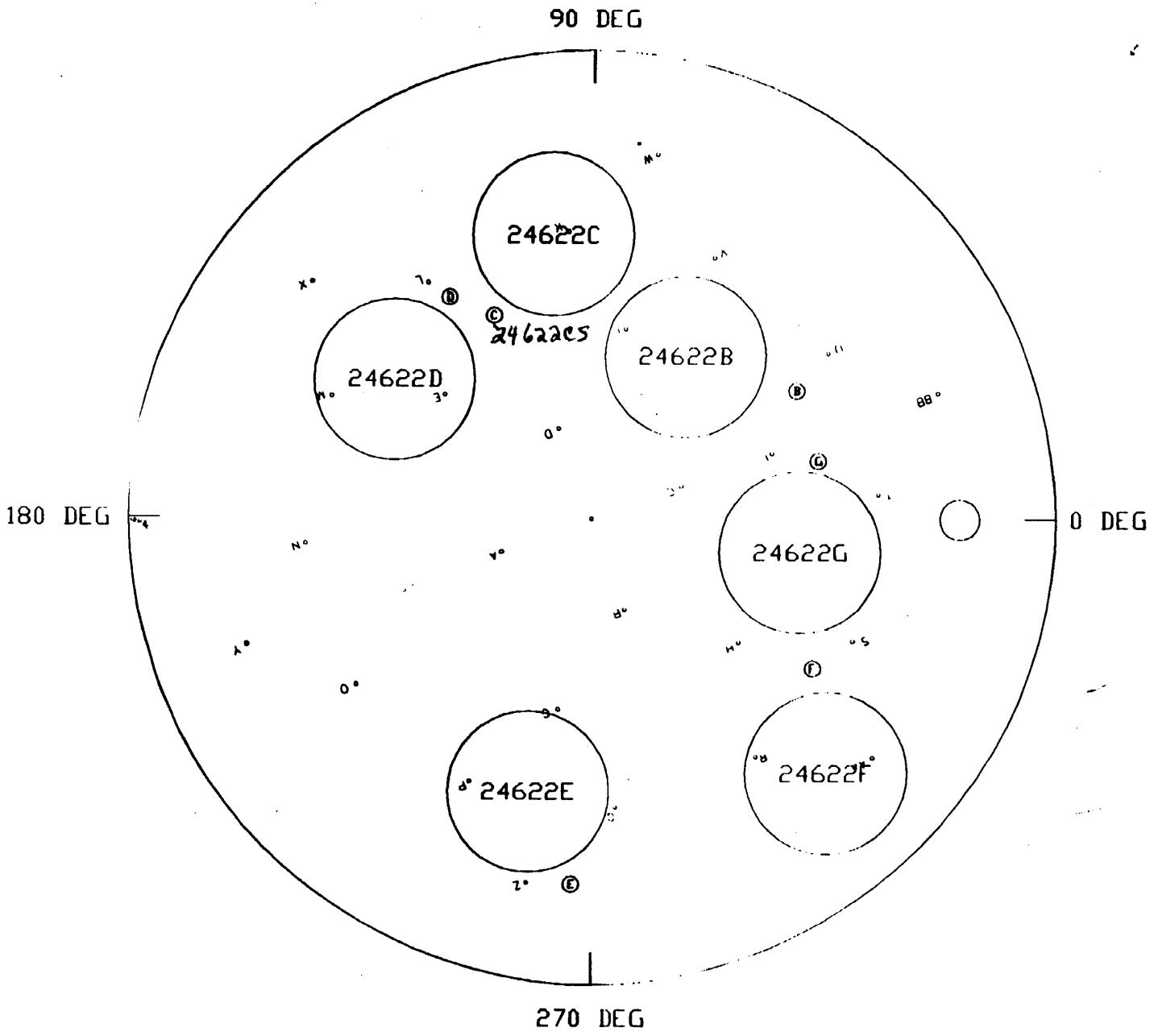
Save Subapt



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

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

24622 FE04


90 DEG
180 DEG
0 DEG
270 DEG
24622C
24622D
24622B
24622G
24622E
24622F

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


MIRROR

Research Electro-Optics Inc.

CERTIFICATE OF CONFORMANCE

Section5.14/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; po# PC162519/CONOS
- Customer Part Number & Revision : LIGOE980065
- Part Description : FM03, FM04; HR@1064nm @ 45°
- REO Job No. : opt05831-019 Run No.: OX745, OX747
- Qty. Shipped/Lot No. : 2 pcs

☒ Test data (included)

Comment:

Certified by: _____, 5/29/98
Quality Assurance

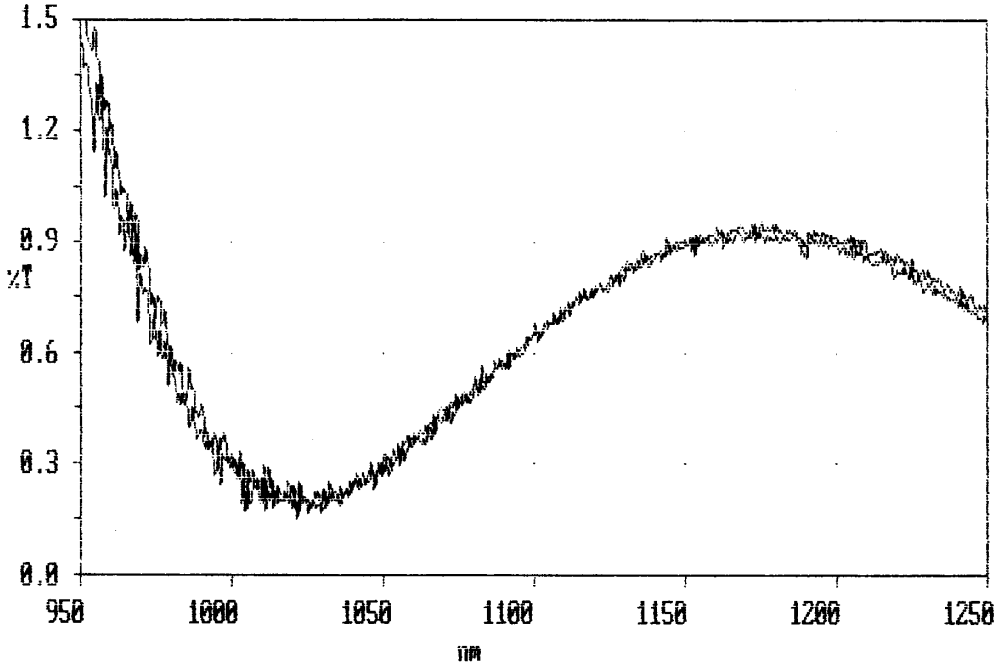
Verified by: Dale C Nolt, 5/29/98
Engr/Tech

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.

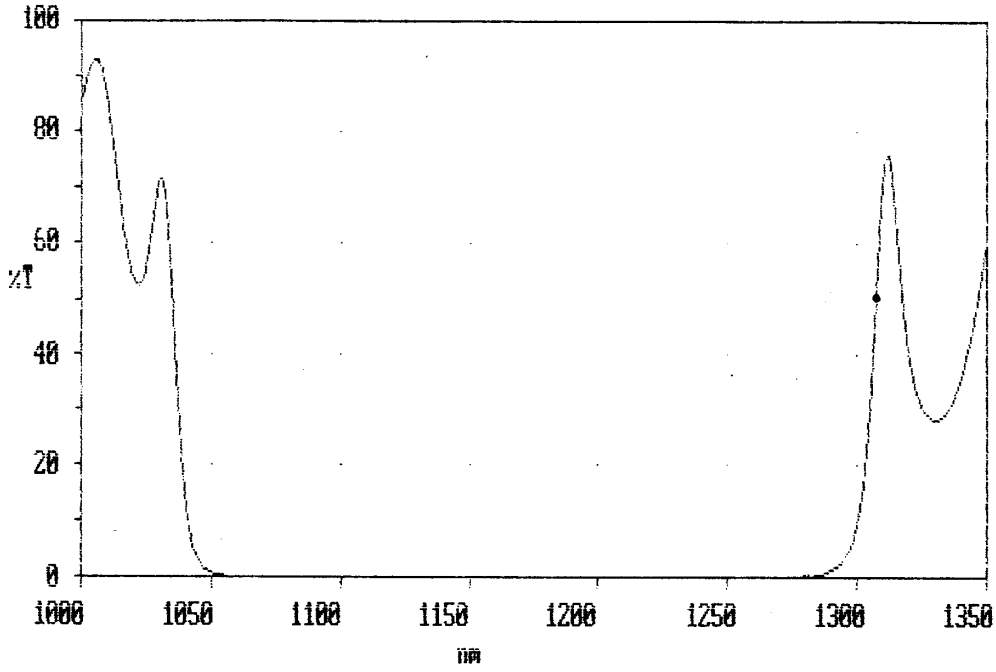
Y: user002: 1250.0 - 950.0 nm; pts 601; int 0.50; ord 0.1447 - 1.6848 %T

Inf: ox747 AR@1064nm @ 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

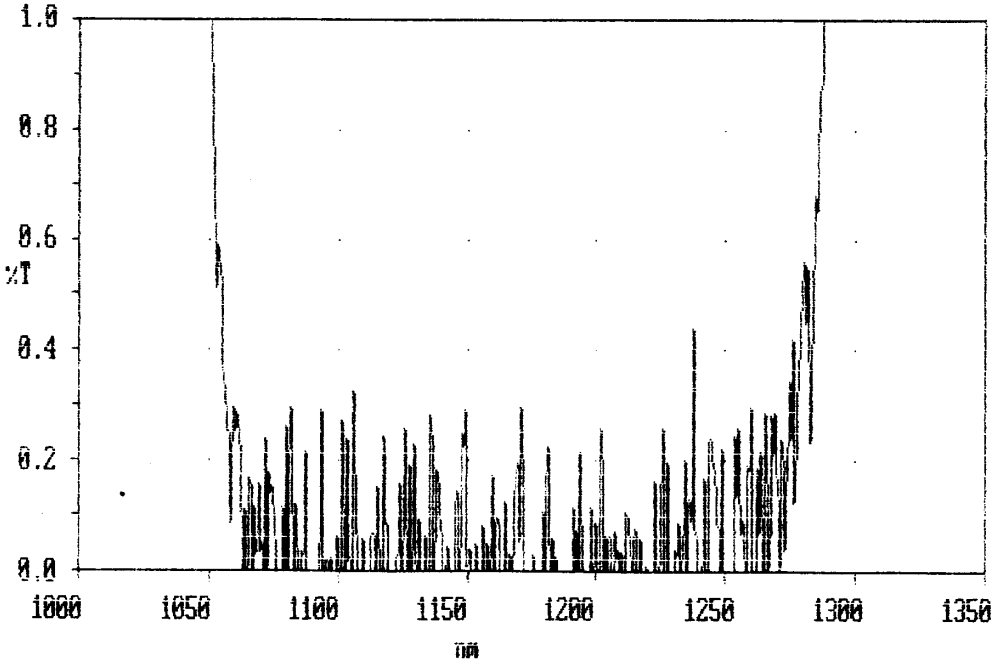


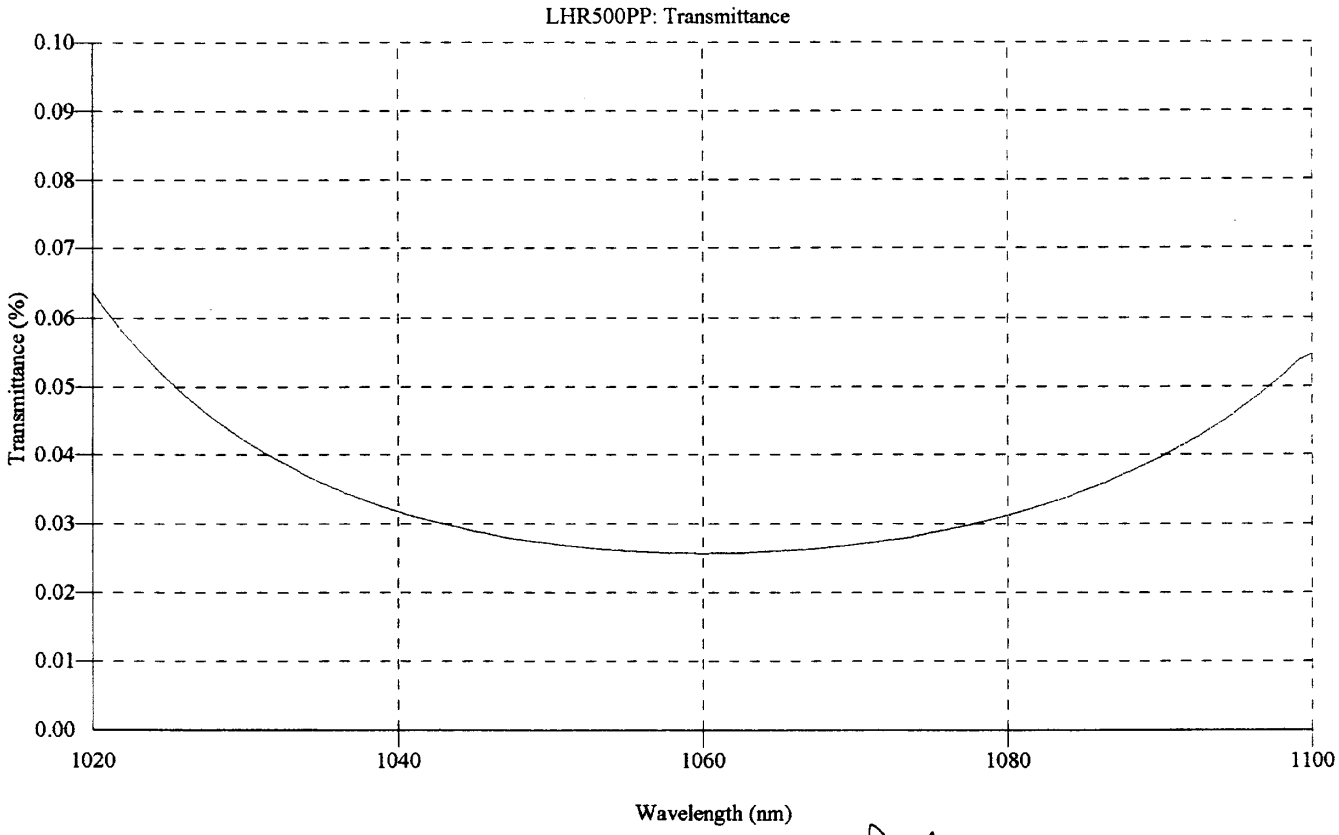
$\lambda_h = 1307.5$

$\lambda_c = 1035.2$

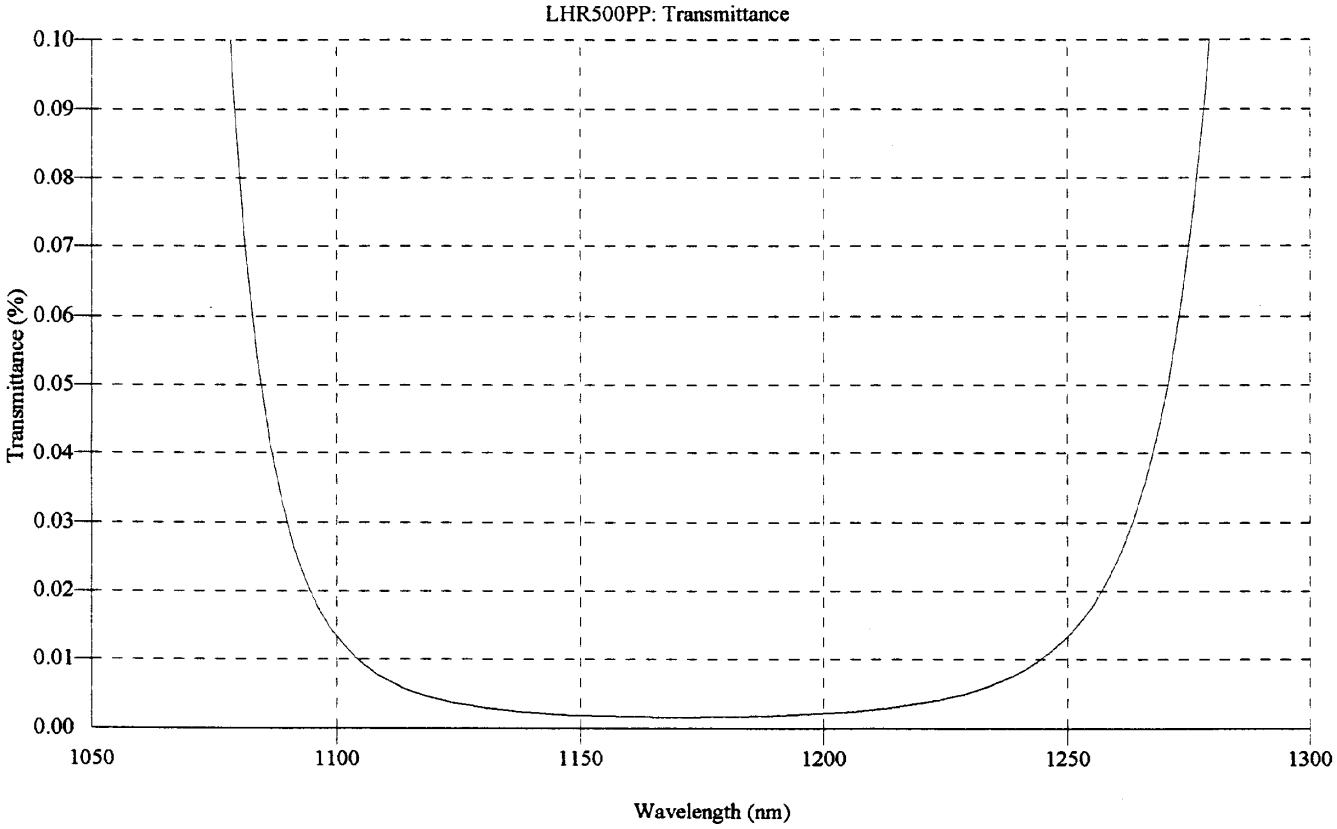
$\lambda_c = 1156$ nm

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

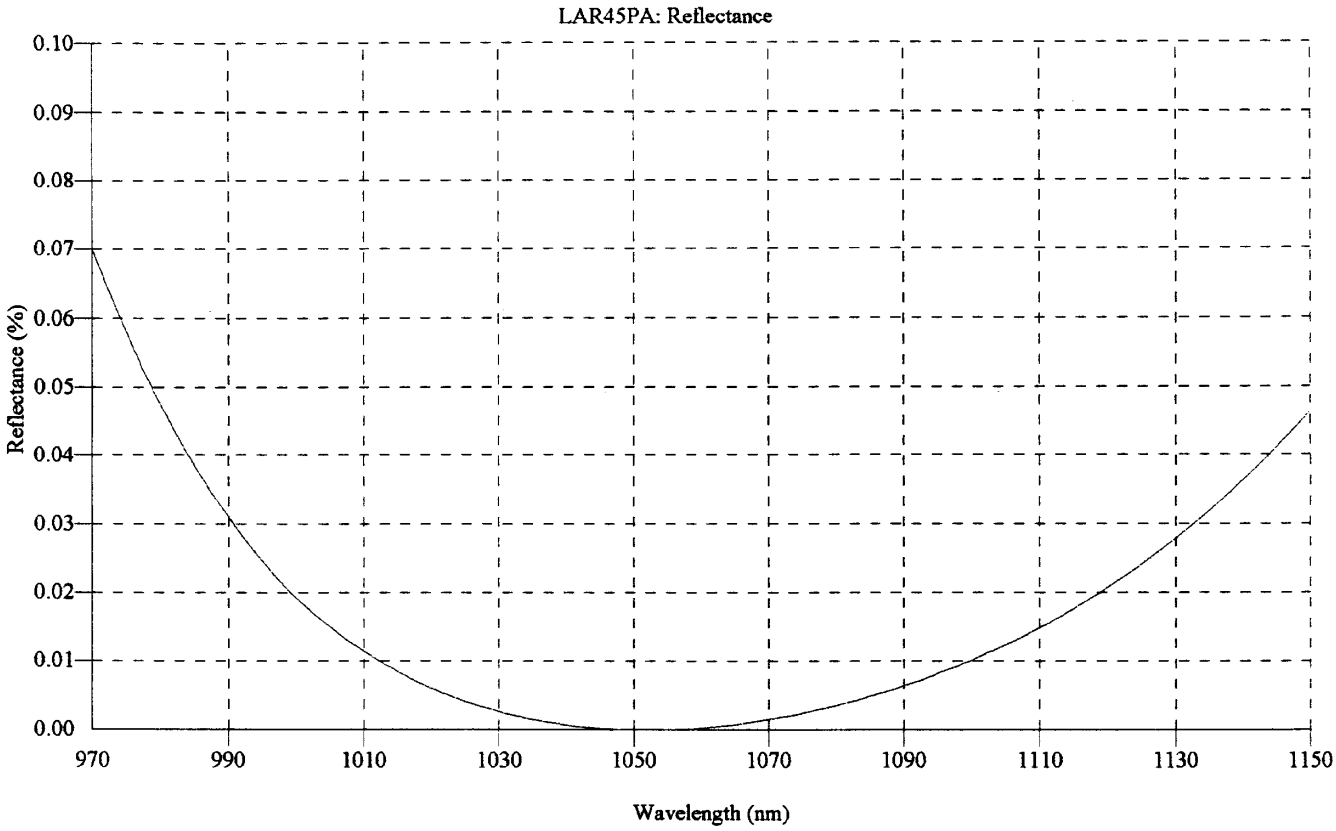




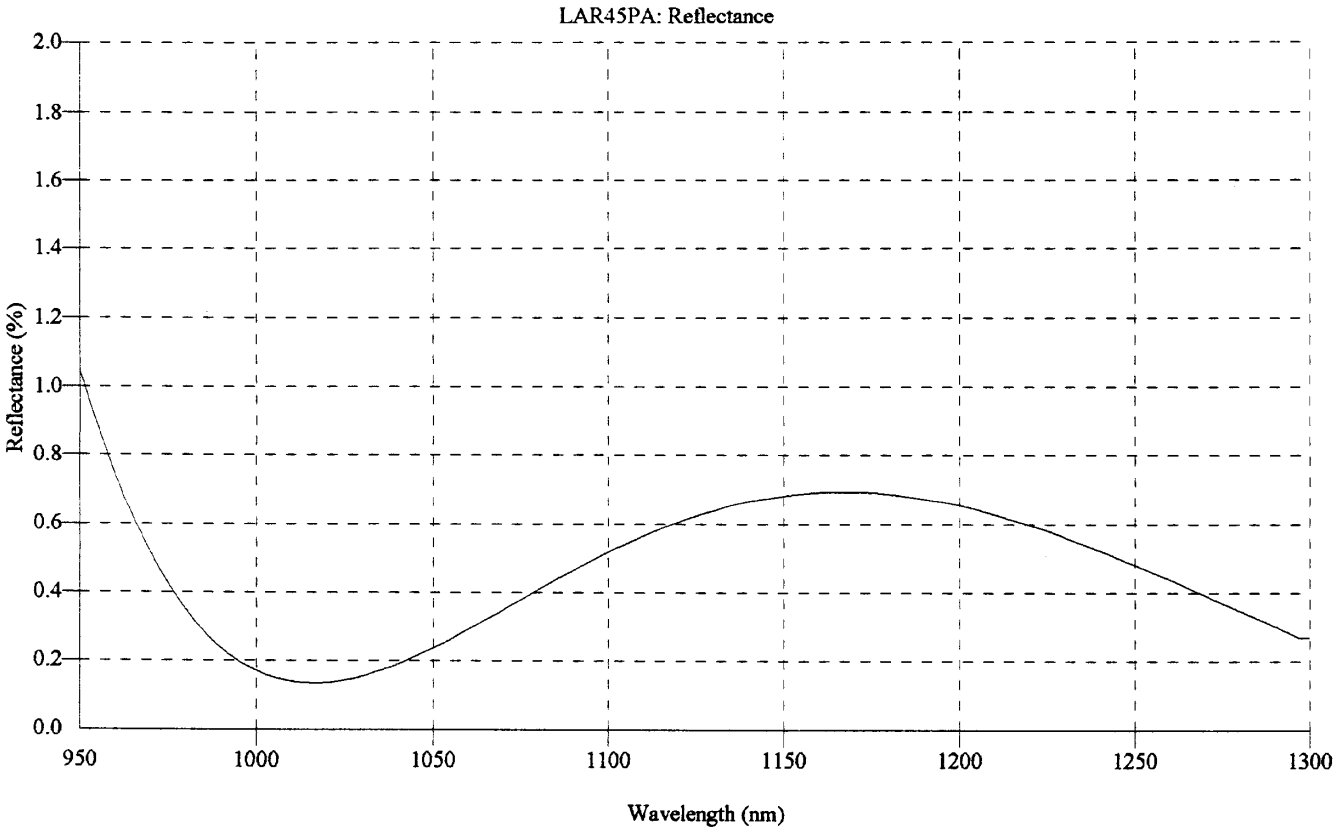
Performance @ 45°



Performance @ 0°



Performance @ 45°



Performance @ 0°

Research Electro-Optics, Inc.

INVOICE NO: 020251
INVOICE DATE: 06/05 1998

I N V O I C E

CUSTOMER NO: 20400
CUSTOMER PH: 626 395 6281
BILL TO:

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

YOUR ORDER NO: PC168513-00005
OUR ORDER NO: OP100831-0004
SHIP TO:

CALIFORNIA INST. OF TECHNOLOGY
51-33 EAST BRIDGE LAB, LIGO
ATTN: HELENA ARMANDULA, 18-34
PASADENA, CA 91125

TERMS: CASH #1: DISC:
CASH #2: DISC:
NET DUE DATE: 070398
YOUR CUSTOMER REP IS: JM

SHIPPED: 06/05 1998
F.O.B.: FACTORY
SHIPMENT NO: 005146 REF:
PRO NO:

QTY ORDERED	QTY SHIPPED	QTY B.O.	ITEM NUMBER	UNIT PRICE	EXTD PRICE
			PER QUO OPQ-2403	[redacted]	[redacted]
			REFERENCE: CALTECH LIGO D-000/LIGO-C... 0-950499-1		
			Technical Contact: Helena Armandula Tel: 626-395-2970 Mail Code 18-34		
			Contractual Representative: Irena Petrac Tel: 626-395-2970 Mail Code 18-34		
			Items #001 thru #014 under PO# PC1685...		
			Items #015 thru #039 under PO# PC168... Per REO quote OPQ-2537 no Item #027 on acknowledgement		
2	2	0	...00065 FOLDING MIRROR, COATED		

CONTINUED ON NEXT PAGE

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

[redacted]

PACKING LIST