

RM03

LIGO-T990161-00-D

SUBSTRATE

A. DCN: LIGO-T970024-01-D

LIGO DETECTOR OPTICS

Page 1 of 3

B. LIGO S/N: RM03-BIncoming 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 167159 D. Substrate Polisher: CSIRO
E. Core optic Material: BS / FM / 2ITM / 4ITM / ETM / (RM) F. Date Received: _____

G Verify glass polisher's Certification with LIGO Component Specification No. E960092-B-D
Attach the completed LIGO Component Specification Verification Sheet.

H Attach a copy of the glass polisher's Certification Document and data sheet to check-off sheet.

I Verify receipt of an IBM PC compatible disc in ASCII format of all Surface Data per the applicable LIGO Component Specification sheet 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.

<input checked="" type="checkbox"/>	Inspection of material diameter.	Diameter	<u>9.88</u> in	<u>250.85</u> mm
<input checked="" type="checkbox"/>	Inspection of material thickness	Thickness	<u>3.84</u> in	<u>97.48</u> mm
<input checked="" type="checkbox"/>	Wedge Angle		<u>2° 24'</u>	

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.

Inspection By: _____ Date Inspected: _____

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: _____

		Serial Number:	Specification	Reported Value	✓
				RMØ3-B	
Surface 1		Surface Figure Over Central 200mm	Spherical, Concave	concave	✓
		Radius of Curvature Tolerance	14,900m +750m -150m	15,390m ± 240	✓
		Astigmatism	< 10nm p-v	3.5 nm p-v	✓
Surface 2		Surface Figure Over Central 200mm	Flat	convex	✓
		Radius of Curvature	> 160 Km	> 600 Km	✓
		Astigmatism	< 32nm p-v	0.1 nm p-v	✓
Surface Errors		Low Spatial Frequency Band Central 80mm	$\leq 4.3 \text{ cm}^{-1}$ $\sigma_{\text{rms}} < 1.6\text{nm}$	0.48 nm	✓
		Low Spatial Frequency Band Central 200mm	$\leq 4.3 \text{ cm}^{-1}$ $\sigma_{\text{rms}} < 3.2\text{nm}$	0.74 nm	✓
		High Spatial Frequency Band Central 80 & 200 mm	$\leq 4.3 - 7,500 \text{ cm}^{-1}$ $\sigma_{\text{rms}} < 0.4\text{nm}$	0.25nm 0.26nm	✓

		ROC		Certification	✓
				is 20m short of max	
Scratches, Point Defects & Polish	Scratches	The Total Area of sc exceed 75×10^3 squ		Hand Sketch w/dimensions	✓
		The total area of scr: exceed 750×10^3 sq		Hand Sketch w/dimensions	✓
	Point Defects	There shall be no m diameter.		Hand Sketch w/dimensions	✓
		There shall be no m 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. S1 Ht. 2.23 44° 34' S2 Ht. 2.26 45° 31'		Inspection Report	✓	

**LIGO Component Specification Verification Sheet
Recycling Mirror**

This Certification Package relates to the following substrate: **Recycling Mirror**

Serial number: RM03B

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 Sides 1 and 2
HABA - LIGO - C - SH:	Certification of Surface Errors - High Frequency, for Sides 1 and 2
Attachment 1	Hard copy print out of LADI data for Side 1 with piston, tilt removed and also for piston, tilt, power, astigmatism removed
Attachment 2	Hard copy print out of LADI data for Side 2 with piston, tilt, removed and also for piston, tilt, power, astigmatism removed
Attachment 3	Hard copy printouts of TOPO 2D data obtained with 2.5X and 40X heads at three central positions (side 1)
Attachment 4	Hard copy printouts of TOPO 2D data obtained with 2.5X and 40X heads at three central positions (side 2)

2. Electronic data

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

LADI data:	RM3B1.ZIP (Side 1)	RM3B2.ZIP (Side 2)
TOPO data: (2.5X)	T2RM031A.ASC (Side 1)	T2RM032A.ASC (Side 2)
	T2RM031B.ASC	T2RM032B.ASC
	T2RM031C.ASC	T2RM032C.ASC
(40X)	T4RM031A.ASC	T4RM032A.ASC
	T4RM031B.ASC	T4RM032B.ASC
	T4RM031C.ASC	T4RM032C.ASC

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:

6.11.97

LIGO Certification Report Side and Bevel Polish

1	Substrate Type:	Recycling Mirror
2	Serial Number:	RM-03B
3	Physical quantity certified:	Side and Bevel Polish
4	LIGO specification reference:	E960092-B-D
5	CSIRO measurement/inspection procedure reference:	HABA-LIGO-M-SB-A
6	Variations to the measurement/inspection procedure: (indicate Yes/No and attach separate sheet if Yes)	No
7	CSIRO Log Book Reference	LN00024
8	Team member responsible for measurement/inspection:	E Pavlovic /J Seckold
9	Measurement/inspection results reviewed by:	A Leistner

10. Results

Defects, if any, in the side and bevel polish compared to the LIGO specification (4 above) are detailed below (*team member to note defects here; if none seen, note "no defects observed"*).

No defects observed.

11. Certification

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

Project Manager:



Chris Walsh

Date:

6.11.97

1	Substrate Type:	Recycling Mirror
2	Serial Number:	RM-03B
3	Physical quantity certified:	Serial Number and location
4	LIGO specification reference:	E960092-B-D
5	CSIRO measurement/inspection procedure reference:	HABA-LIGO-M-SN-A
6	Variations to the measurement/inspection procedure: (indicate Yes/No and attach separate sheet if Yes)	No
7	CSIRO Log Book Reference	LN00024
8	Team member responsible for measurement/inspection:	E Pavlovic / J Seckold
9	Measurement/inspection results reviewed by:	A Leistner


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

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Project Manager:



Chris Walsh

Date:

6.11.97

1	Substrate Type:	Recycling Mirror
2	Serial Number:	RM-03B
3	Physical quantity certified:	Scratches and Point Defects
4	LIGO specification reference:	E960092-B-D
5	CSIRO measurement/inspection procedure reference:	HABA-LIGO-M-SP-A
6	Variations to the measurement/inspection procedure: (indicate Yes/No and attach separate sheet if Yes)	No
7	CSIRO Log Book Reference	LN00024
8	Team member responsible for measurement/inspection:	E Pavlovic / J Seckold
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	none	none
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:


6.11.97

Chris Walsh

Date:

1	Substrate Type:	Recycling Mirror
2	Serial Number:	RM-03B
3	Physical quantity certified:	Surface Figure
4	LIGO specification reference:	E960092-B-D
5	CSIRO measurement/inspection procedure reference:	HABA-LIGO-M-SF-A
6	Variations to the measurement/inspection procedure: (indicate Yes/No and attach separate sheet if Yes)	No
7	CSIRO Log Book Reference	LN00061, pp. 3-4
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	15.39 ± 0.24 (concave)	3.5	RM3B1.ZIP
Surface 2	> 600 (convex)	0.1	RM3B2.ZIP

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:

6.11.97

1	Substrate Type:	Recycling Mirror
2	Serial Number:	RM-03B
3	Physical quantity certified:	Surface Errors - Low Spatial Frequency
4	LIGO specification reference:	E960092-B-D
5	CSIRO measurement/inspection procedure reference:	HABA-LIGO-M-SL-A
6	Variations to the measurement/inspection procedure: (indicate Yes/No and attach separate sheet if Yes)	No
7	CSIRO Log Book Reference	LN00061, pp. 3-4
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	0.48	0.74
Surface 2	0.50	1.38

Hardcopies of the phase maps over the central 200 mm with piston, tilt, power and astigmatism removed are attached to this certification in Attachment 1 for Side 1 and Attachment 2 for Side 2.

11. Certification

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

Project Manager:


6.11.97

Chris Walsh

Date:

1	Substrate Type:	Recycling Mirror
2	Serial Number:	RM-03B
3	Physical quantity certified:	Surface Errors - high spatial frequency
4	LIGO specification reference:	E960092-B-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
7	CSIRO Log Book Reference	LN00066, pp.58-64, 94-97, 110-113
8	Team member responsible for measurement/inspection:	F Lesha
9	Measurement/inspection results reviewed by:	C Walsh

10. Results

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

Side 1: 0.25

Side 2: 0.18

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

Side 1: 0.26

Side 2: 0.19

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

	A	B	C	D	E	F	G	H
Surface 1	0.26	0.26	0.25	0.22	0.27	0.27	0.29	0.28
Surface 2	0.20	0.16	0.18	0.19	0.19	0.17	0.20	0.21

Two - dimensional surface maps at three central locations are available at the CSIRO ftp site under filenames of the form TORM0YZA.asc, where O is the objective used (O=2 for 2.5X, 4 for 40X), RM is the substrate type, 0Y is the number, Z = 1 or 2 is the side and A = A, B, C, ... is the sampling position. Hard copies of the data are at Attachment 3 (Side 1) and Attachment 4 (Side 2).

11. Certification

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

Project Manager:



Chris Walsh

Date:

6.11.97

Att. 1

LADI CERTIFICATION DATA

CSIRO

Title: RM3B1

Date: 10/24/97

Diameter: 200 mm

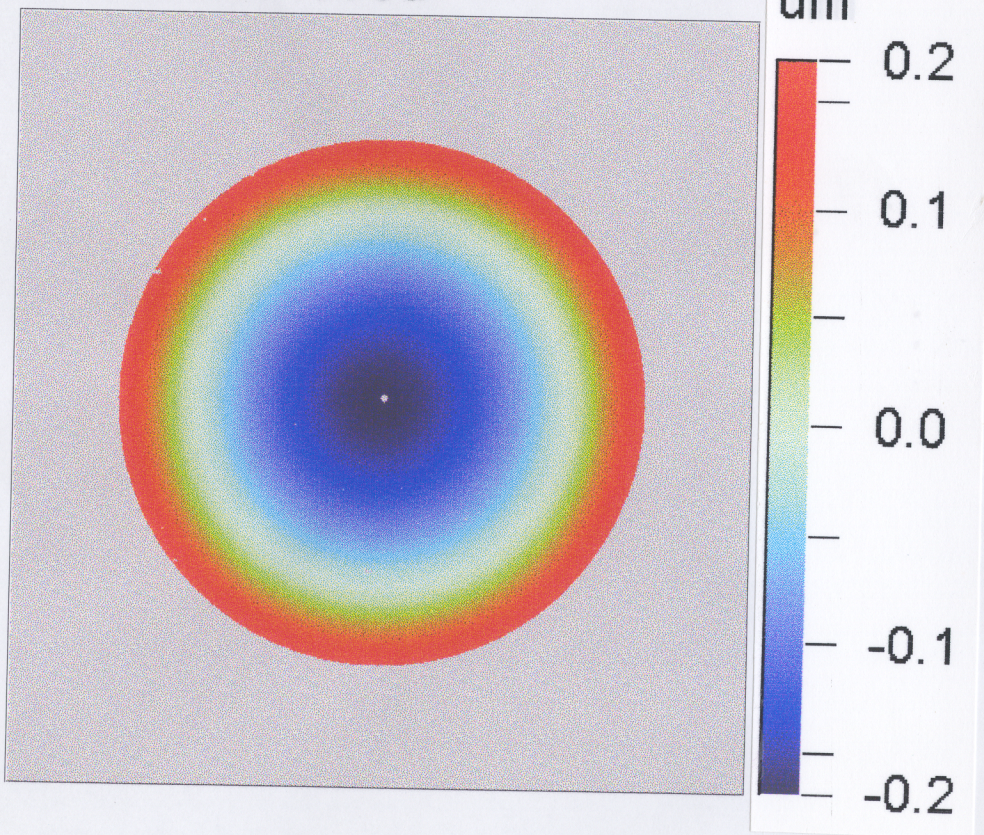
Astig: 3.5 nm

Power: 324.9 nm

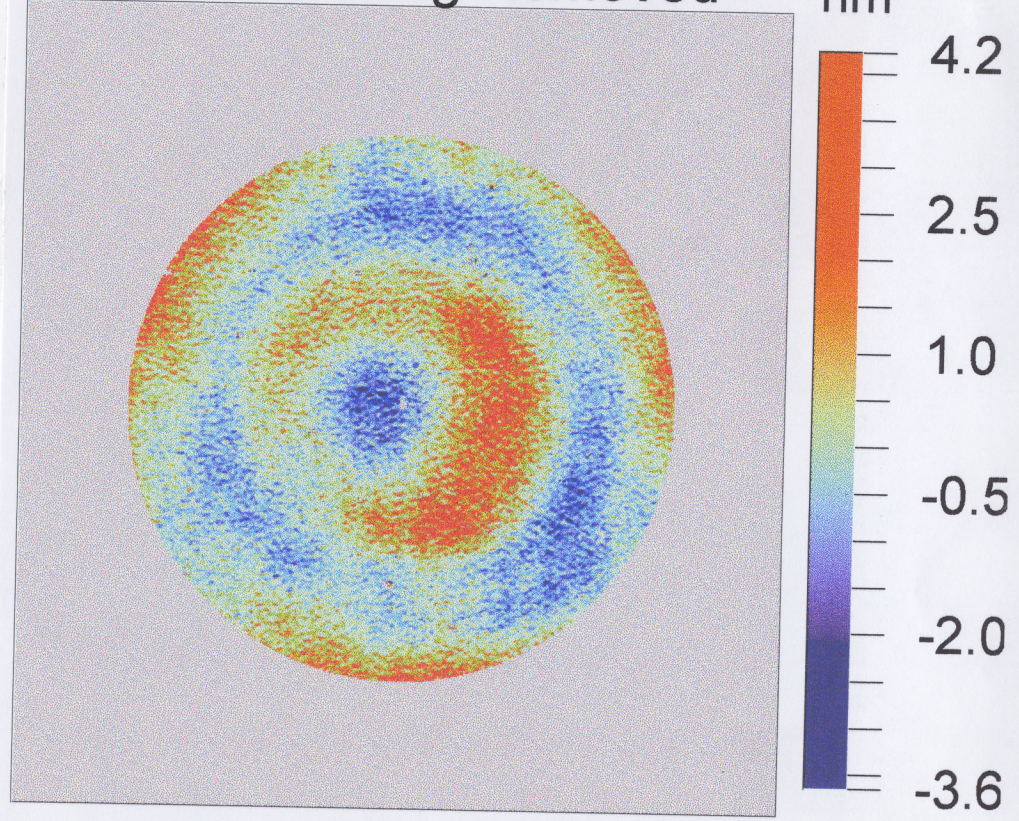
PV: 7.9 nm

RMS: 0.7 nm

Tilt Removed



Tilt/Power/Astig Removed



Att. 2

LADI CERTIFICATION DATA

CSIRO

Title: RM3B2

Date: 10/24/97

Diameter: 200 mm

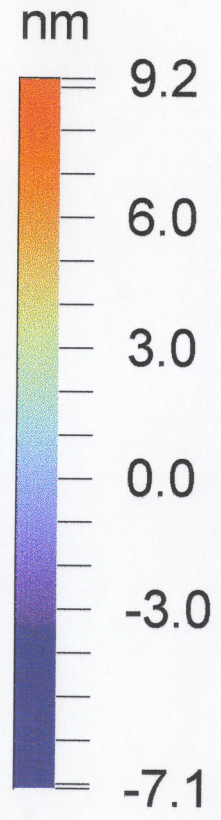
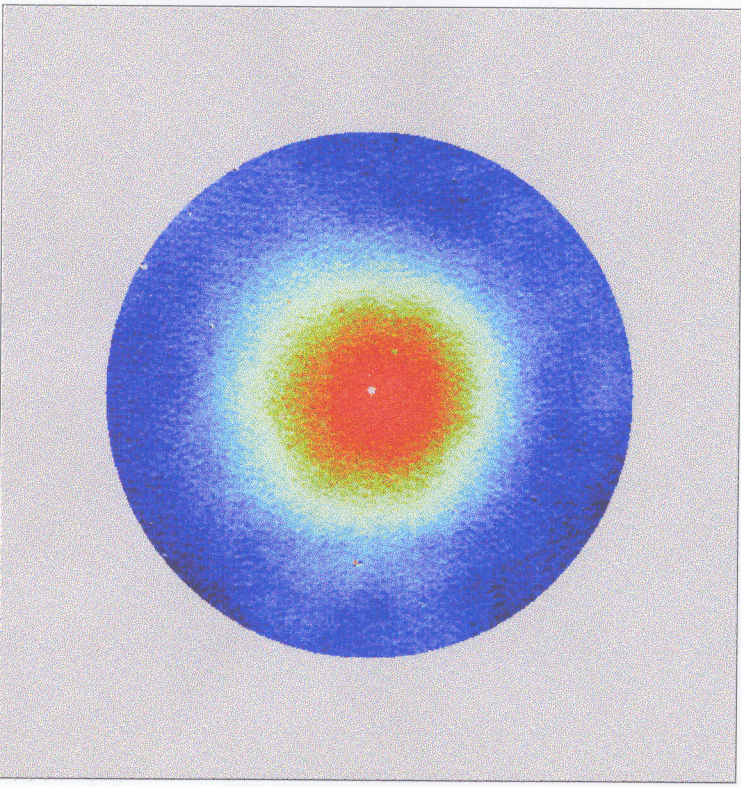
Astig: -0.1 nm

Power: -8.0 nm

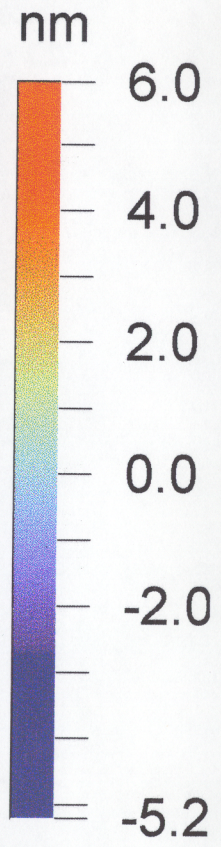
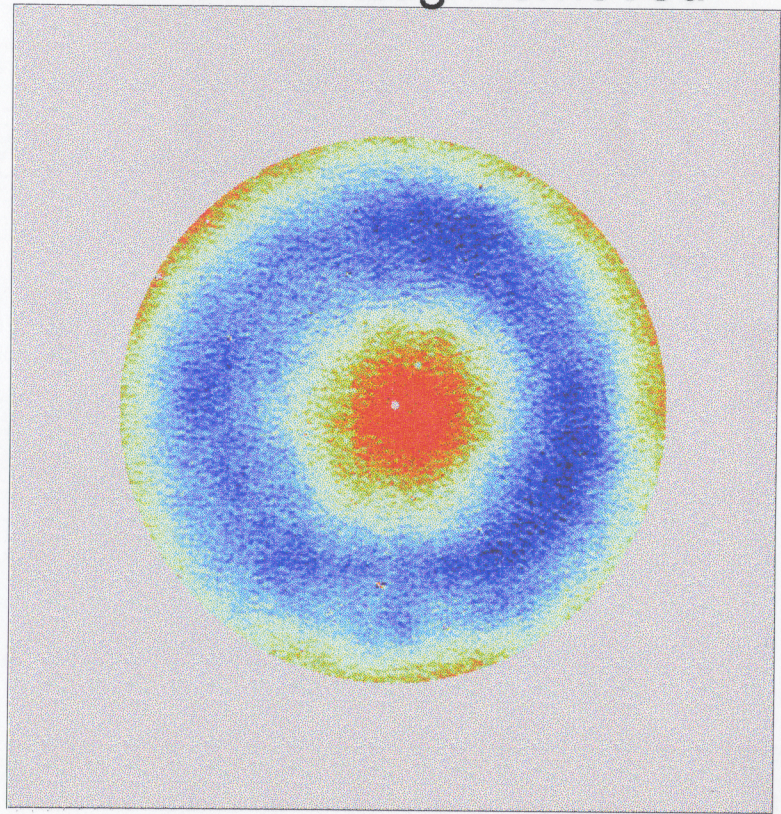
PV: 11.2 nm

RMS: 1.4 nm

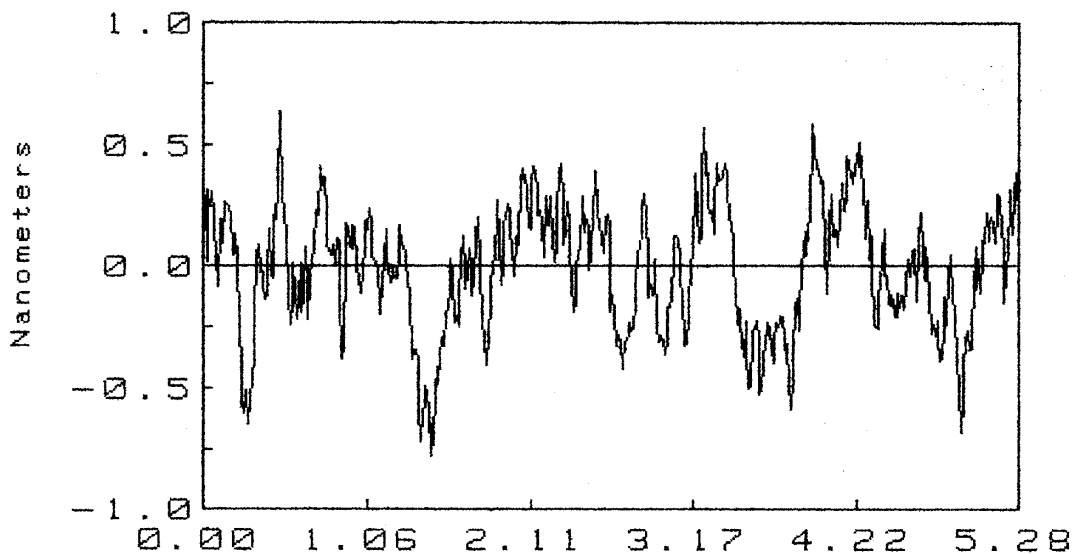
Tilt Removed



Tilt/Power/Astig Removed

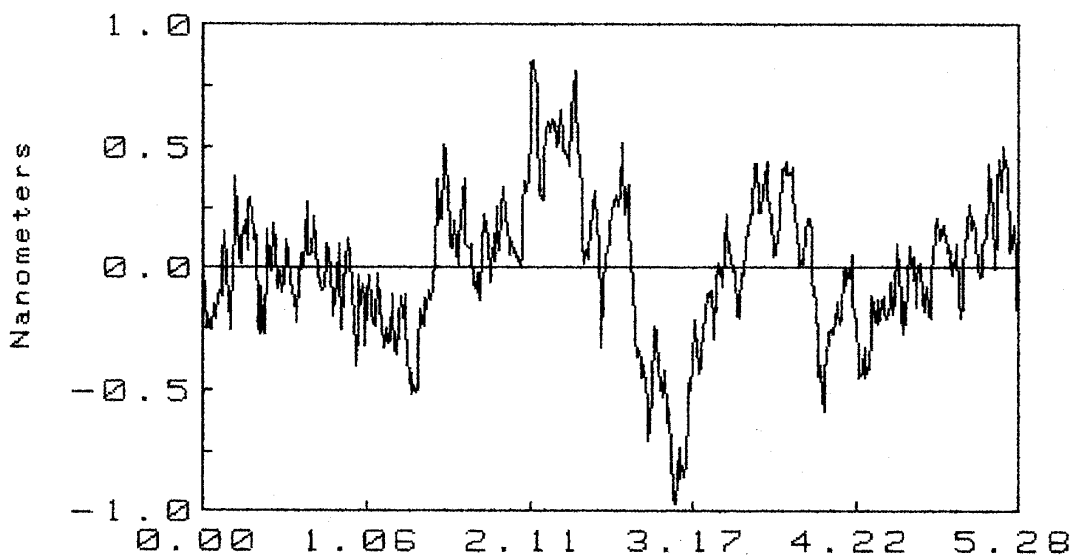


RM31A1 Time: 20:08 Date: 10/21/97
RMS: 0.264nm PV: 1.48nm
RA: 0.215nm Ref. Subtracted RC: -96.1 km



T2RM031A.ASC WYKO

RM31B3 Time: 20:49 Date: 10/21/97
RMS: 0.298nm PV: 1.86nm
RA: 0.230nm Ref. Subtracted RC: 9628 m



T2RM031B.ASC WYKO

Att.3

RM31C2

Time: 20:52

Date: 10/21/97

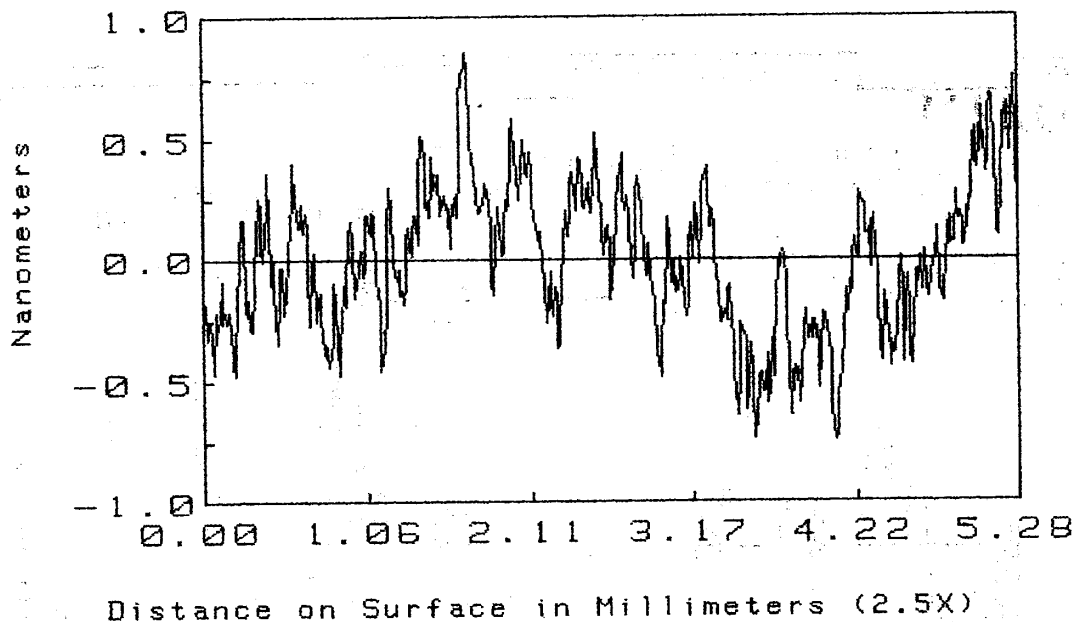
RMS: 0.302nm

PV: 1.60nm

RA: 0.248nm

Ref. **PROFILE**
Subtracted

RC: -18.7 km



T2RMO3IC.ASC

WYKO

RM31A5

Time: 16:17

Date: 10/23/97

RMS: 0.192nm

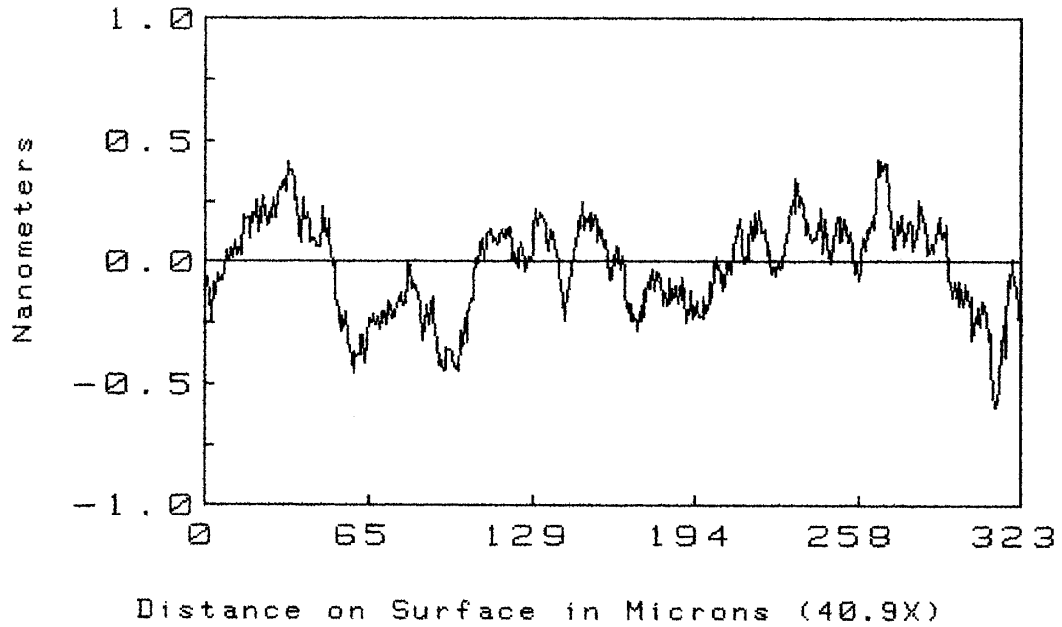
PV: 1.15nm

RA: 0.158nm

Ref. Subtracted

RC: -30.3 m

PROFILE



T4RM031A.ASC

WYKO

RM31B4

Time: 16:20

Date: 10/23/97

RMS: 0.194nm

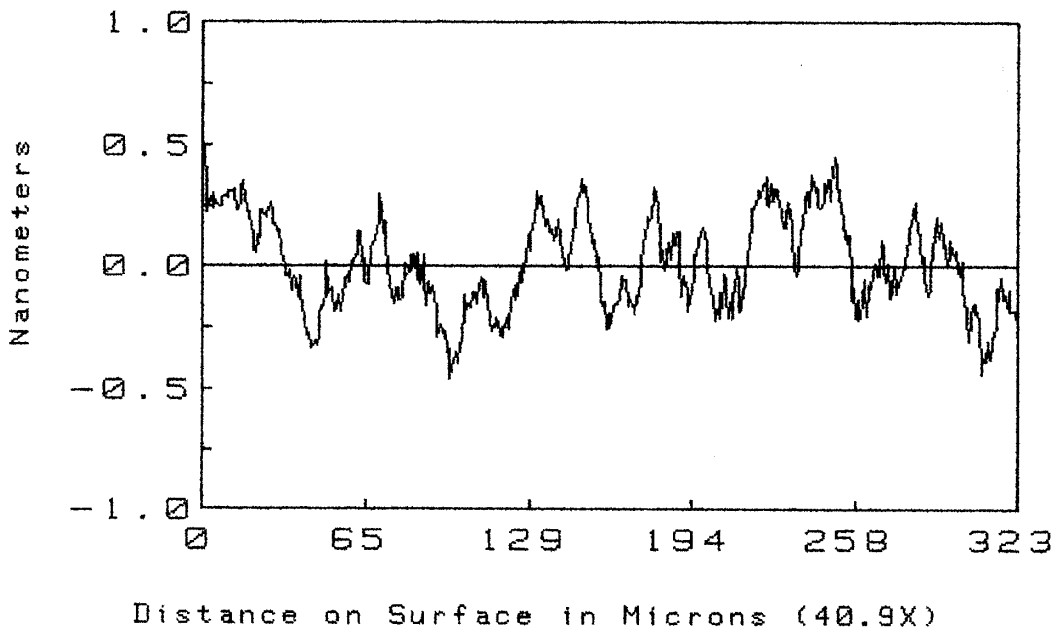
PV: 1.01nm

RA: 0.163nm

Ref. Subtracted

RC: -18.7 m

PROFILE



T4RM031B.ASC

WYKO

RM31C5

Time: 16:27

Date: 10/23/97

RMS: 0.215nm

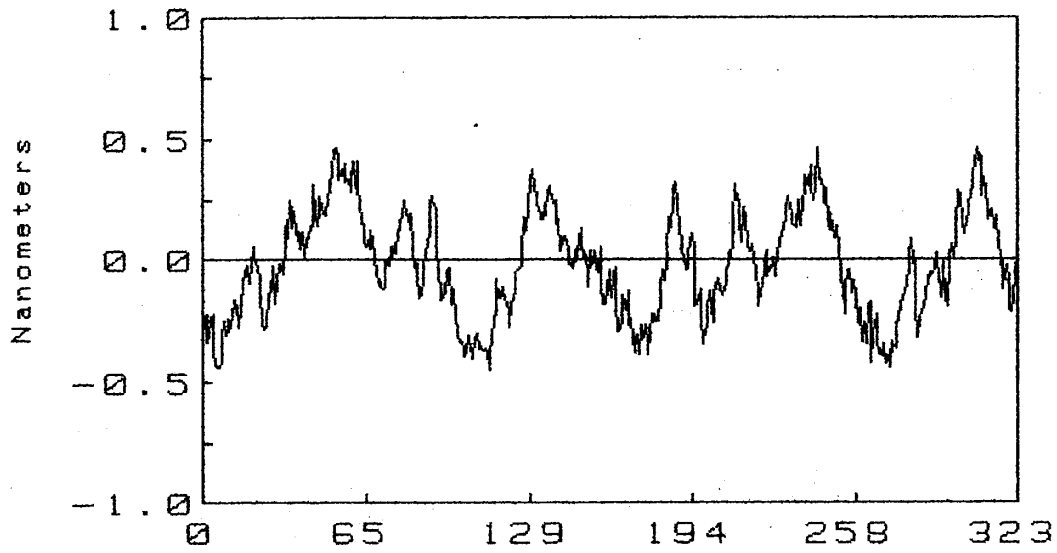
PV: 0.949nm

RA: 0.179nm

Ref. Subtracted

RC: 41.2 m

PROFILE



Distance on Surface in Microns (40.9X)

T4RMO3IC.ASC

WYKO

RM32A2

Time: 2:31

Date: 10/22/97

RMS: 0.215nm

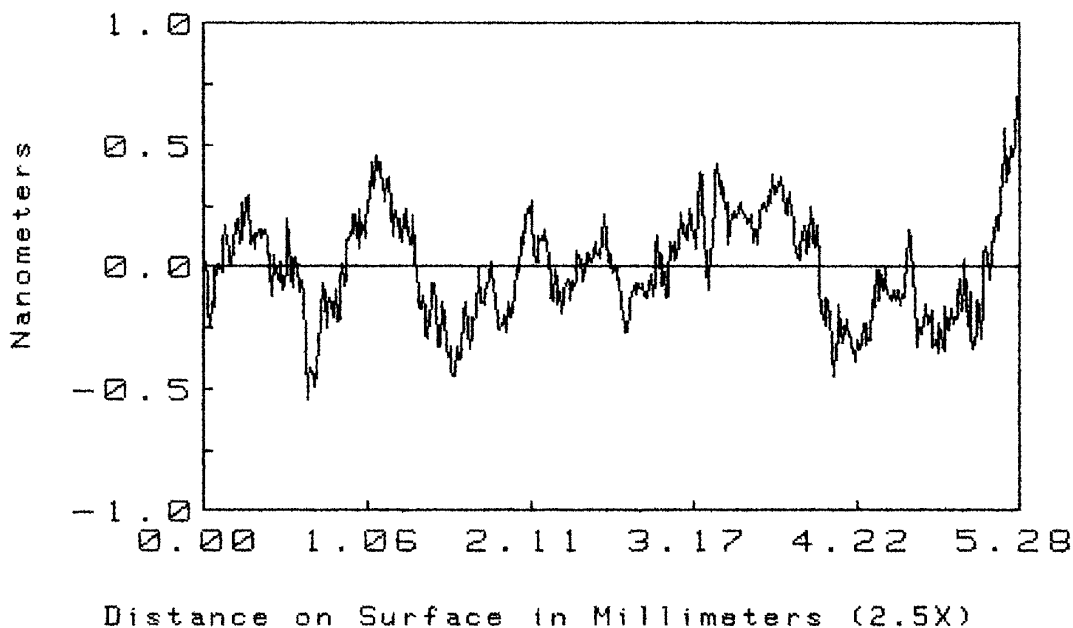
PROFILE

PV: 1.24nm

RA: 0.177nm

Ref. Subtracted

RC: -5872 m



T2RM032A.ASC WYKO

RM32B1

Time: 2:33

Date: 10/22/97

RMS: 0.205nm

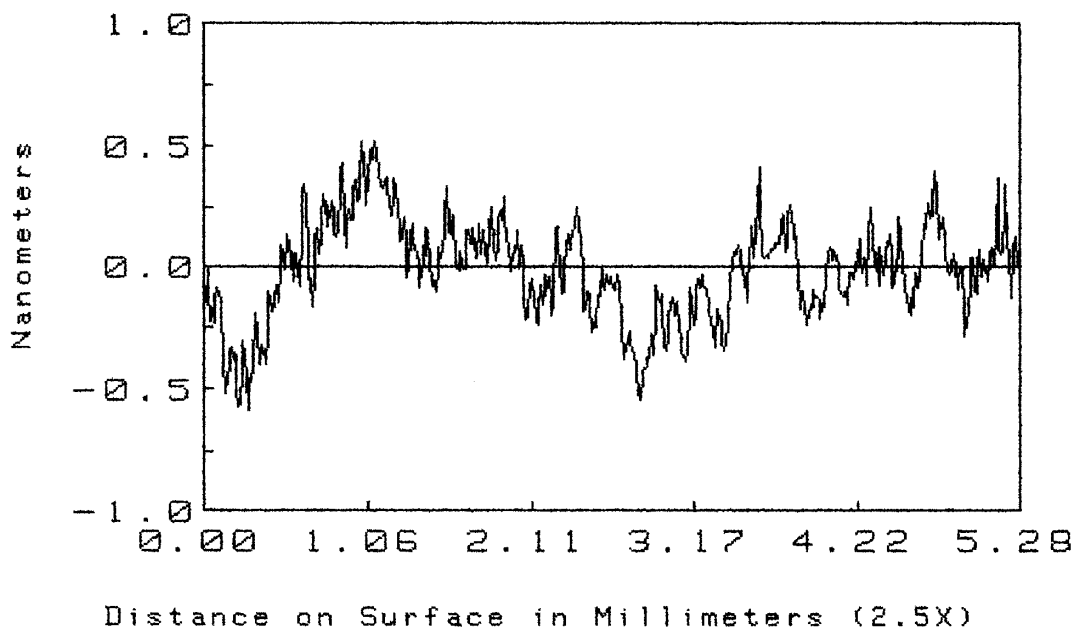
PROFILE

PV: 1.17nm

RA: 0.162nm

Ref. Subtracted

RC: -90.0 km



T2RM032B.ASC WYKO

Attach. 4

RM32C2

Time: 2:38

Date: 10/22/97

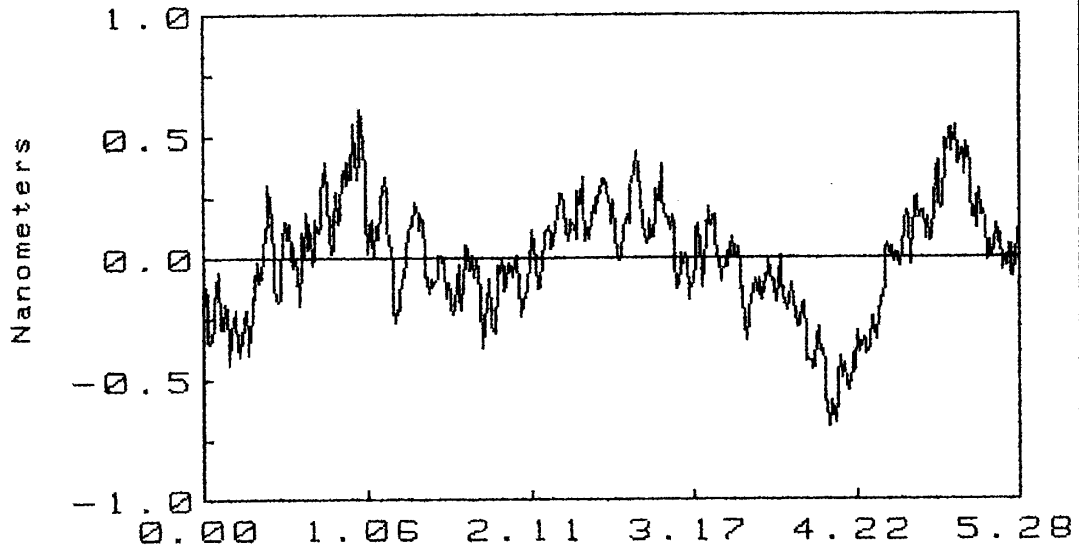
RMS: 0.234nm

PV: 1.30nm

RA: 0.185nm

PROFILE
Ref. Subtracted

RC: 12.9 km



Distance on Surface in Millimeters (2.5X)

T2RM032C.ASC

WYKO

RM32A4

Time: 12:08

Date: 10/23/97

RMS: 0.114nm

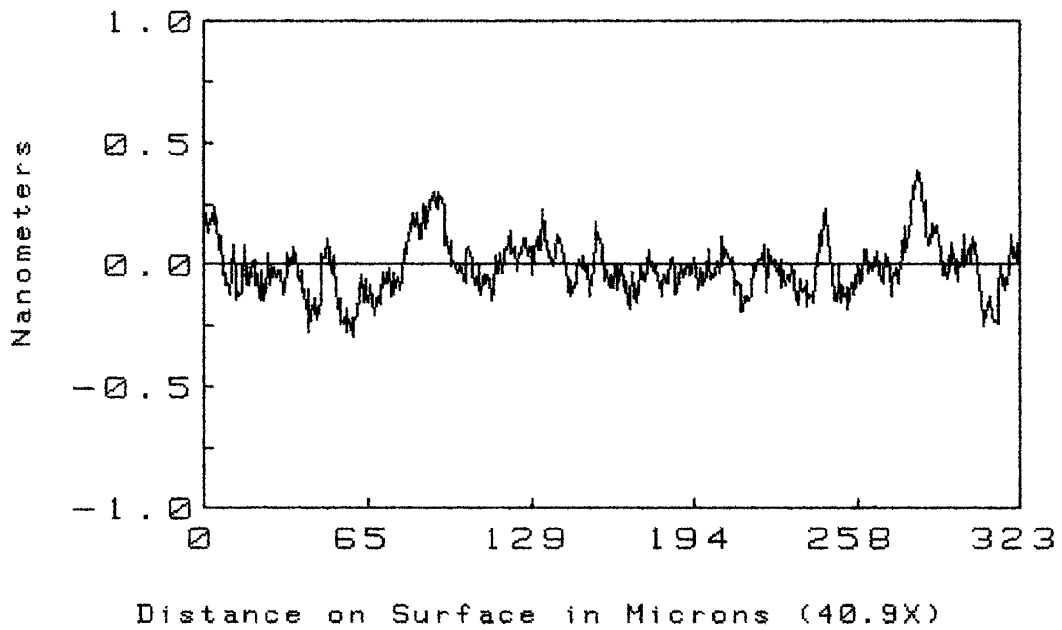
PV: 0.681nm

RA: 0.087nm

Ref. Subtracted

RC: -22.2 m

PROFILE



T4RM032A.ASC

WYKO

RM32B6

Time: 12:23

Date: 10/23/97

RMS: 0.131nm

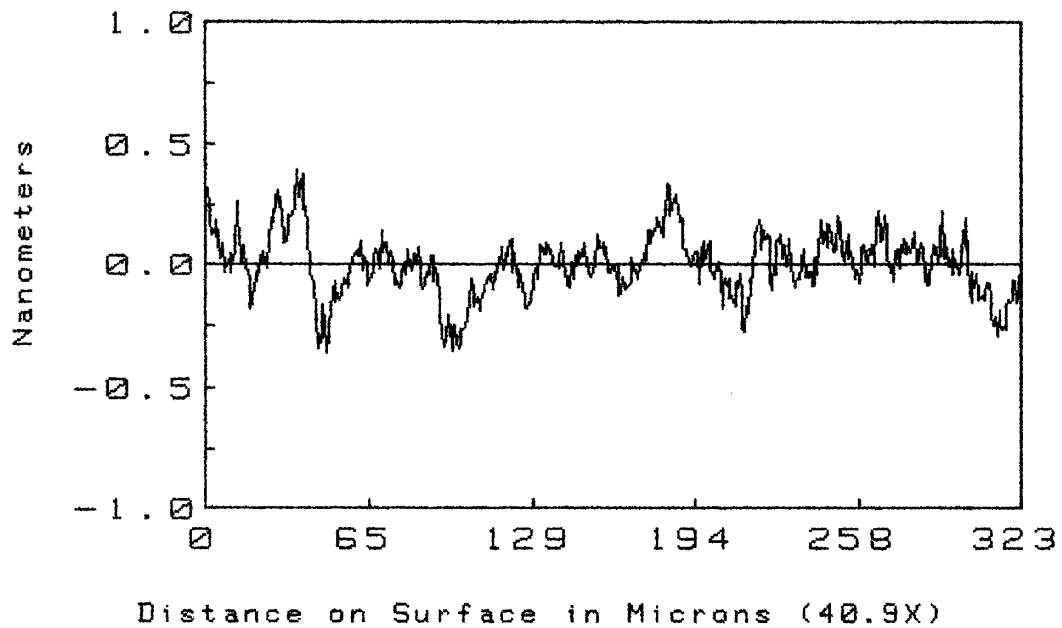
PV: 0.792nm

RA: 0.100nm

Ref. Subtracted

RC: -65.8 m

PROFILE



T4RM032B.ASC

WYKO

RM32C6

Time: 12:29

Date: 10/23/97

RMS: 0.123nm

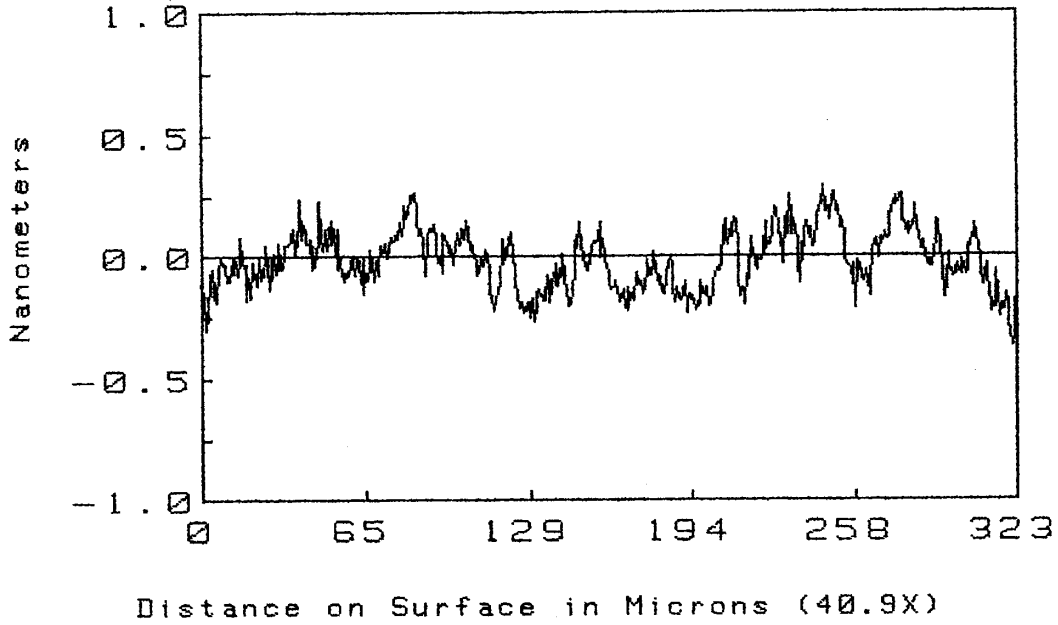
PV: 0.673nm

RA: 0.101nm

Ref. Subtracted

RC: -48.0 m

PROFILE



T4RM032C.ASC WYKO