

RM04

LIGO-T990162-00-D

SUBSTRATE

A. DCN: LIGO-T970025-01-D

LIGO DETECTOR OPTICS

Page ___ of ___

B. LIGO S/N: RM04-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: CSIROE. 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 siteJ 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 EngineerL 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>250.84</u> mm
<input checked="" type="checkbox"/>	Inspection of material thickness	Thickness	<u>3.84</u> in	<u>97.47</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	✓
				RM04-B	
Surface 1		Surface Figure Over Central 200mm	Spherical, Concave	Concave	✓
		Radius of Curvature Tolerance	14,900m +750m -150m	15,000m ± 240	✓
		Astigmatism	< 10nm p-v	1.5nm p-v	✓
Surface 2		Surface Figure Over Central 200mm	Flat	Concave	✓
		Radius of Curvature	> 160 Km	1700 Km	✓
		Astigmatism	< 32nm p-v	1.6nm 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	$\leq 4.3 \text{ cm}^{-1}$ $\sigma_{\text{rms}} < 3.2\text{nm}$	0.67 nm	✓
		High Spatial Frequency Band Central 80 & 200 mm	$\leq 4.3 - 7,500 \text{ cm}^{-1}$ $\sigma_{\text{rms}} < 0.4\text{nm}$		

		Specification	Certification	✓
Scratches, Point Defects & Polish	Scratches	The Total Area of scratches within the central 80mm diameter shall not exceed 75×10^3 square micrometers (width x length).	Hand Sketch w/dimensions	✓
		The total area of scratches outside the central 80 mm diameter shall not exceed 750×10^3 square micrometers.	Hand Sketch w/dimensions	✓
	Point Defects	There shall be no more than 30 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. S1 Ht. 2.25 45° 20' S2 Ht. 2.30 44° 39'	Inspection Report	✓

LIGO Component Specification Verification Sheet Recycling Mirror

LIGO Certification Package

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

Serial number: RM04B

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:	RM4B1.ZIP (Side 1)	RM4B2.ZIP (Side 2)
TOPO data: (2.5X)	T2RM041A.ASC (Side 1)	T2RM042A.ASC (Side 2)
	T2RM041B.ASC	T2RM042B.ASC
	T2RM041C.ASC	T2RM042C.ASC
(40X)	T4RM041A.ASC	T4RM042A.ASC
	T4RM041B.ASC	T4RM042B.ASC
	T4RM041C.ASC	T4RM042C.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-04B
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-04B
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)	Located on opposite side of disk to that specified in dwg.
Orientation of serial number as per drawing (sec. 4)	OK
Height of lettering	OK

11. Certification

The measurements and inspection data presented in this report were obtained using the procedures outlined in the relevant CSIRO procedures document (sec. 5). These results have been reviewed against the LIGO specifications (sec. 4). Taking into account the variations (if any) from these measurement procedures noted in sec.6, CSIRO certifies the substrate to comply with the LIGO specification for this physical quantity with the exception of the variations noted in section 10.

Project Manager:



Chris Walsh

Date:

6.11.97

1	Substrate Type:	Recycling Mirror
2	Serial Number:	RM-04B
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	8000

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-04B
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. 5-7
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	15.00 ± 0.24 (concave)	1.5	RM4B1.ZIP
Surface 2	1700 (concave)	1.6	RM4B2.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
6.11.97

Chris Walsh

Date:

1	Substrate Type:	Recycling Mirror
2	Serial Number:	RM-04B
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. 5-7
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	0.67
Surface 2	0.44	0.55

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:

Chris Walsh
6.11.97

Chris Walsh

Date:

1	Substrate Type:	Recycling Mirror
2	Serial Number:	RM-04B
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-A
6	Variations to the measurement/inspection procedure: (indicate Yes/No and attach separate sheet if Yes)	No
7	CSIRO Log Book Reference	LN0066, pp.54-57, 66-69, 98-101, LLN/0091 pp. 2-5
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: 0.30
Side 2: 0.20

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

Side 1: 0.31
Side 2: 0.20

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

	A	B	C	D	E	F	G	H
Surface 1	0.31	0.31	0.29	0.32	0.28	0.36	0.35	0.29
Surface 2	0.21	0.21	0.21	0.18	0.19	0.20	0.20	0.19

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

LADI CERTIFICATION DATA

CSIRO

Title: RM4B1

Date: 10/27/97

Diameter: 200 mm

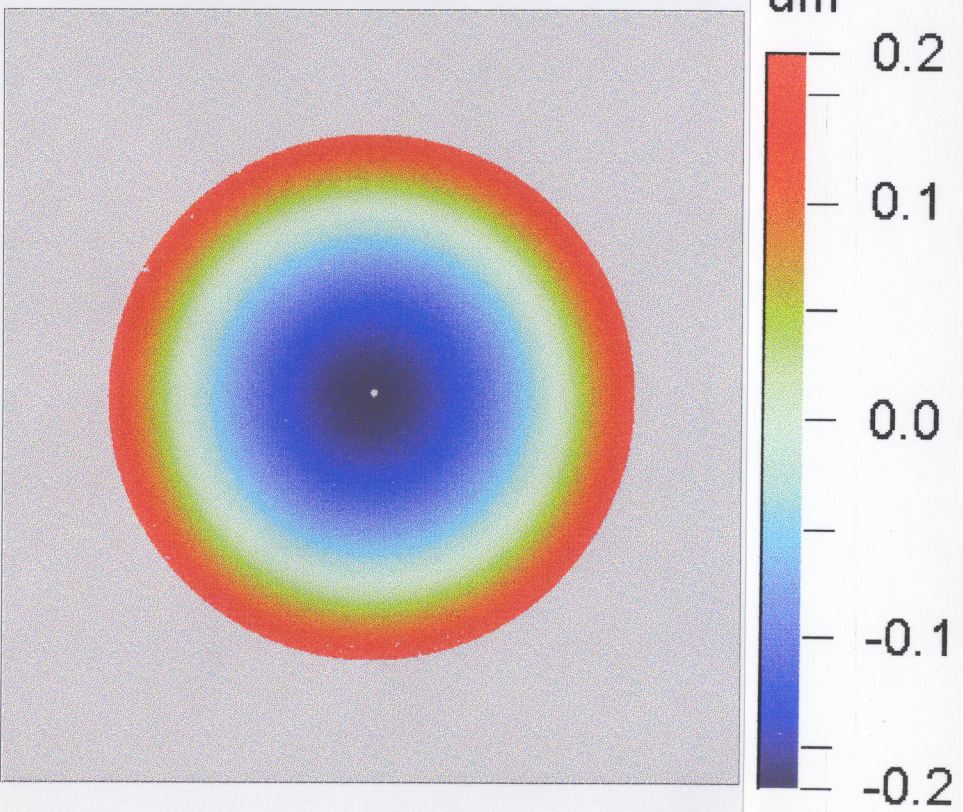
Astig: 1.5 nm

Power: 333.4 nm

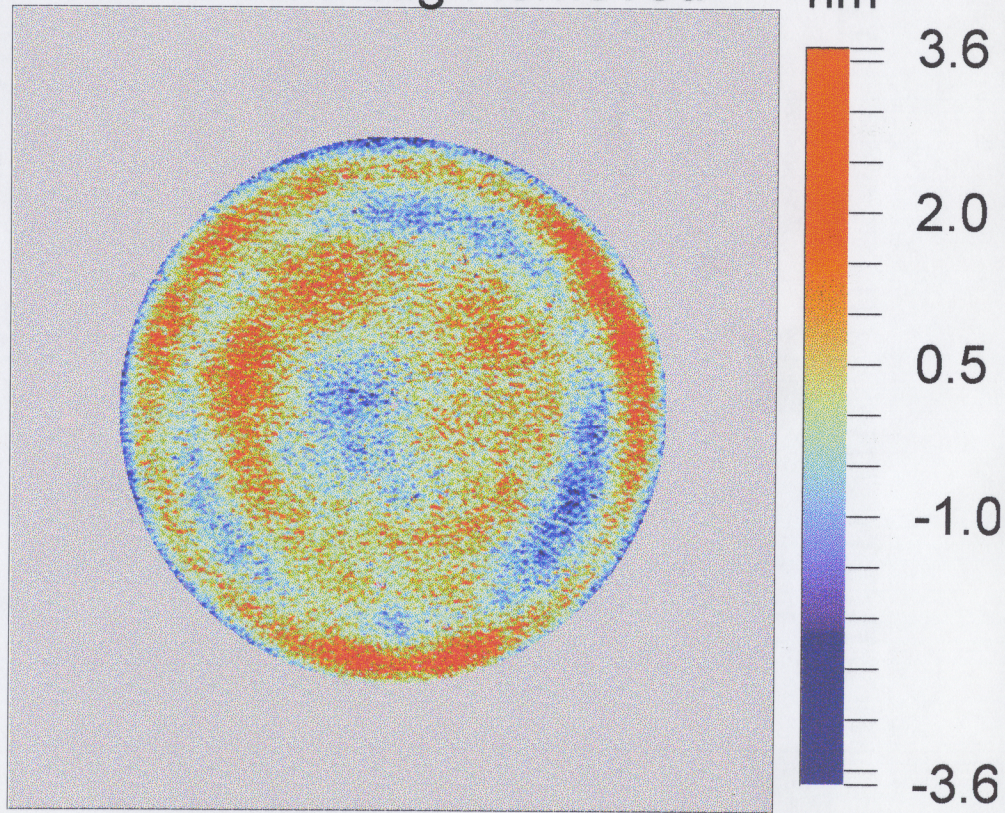
PV: 7.3 nm

RMS: 0.7 nm

Tilt Removed



Tilt/Power/Astig Removed



LADI CERTIFICATION DATA

CSIRO

Title: RM4B2

Date: 10/27/97

Diameter: 200 mm

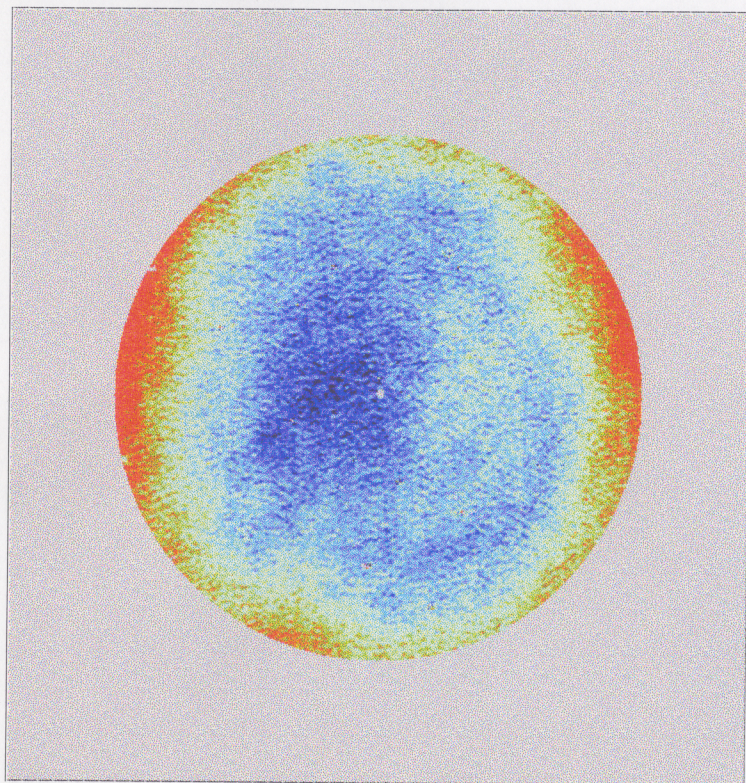
Astig: 1.6 nm

Power: 2.9 nm

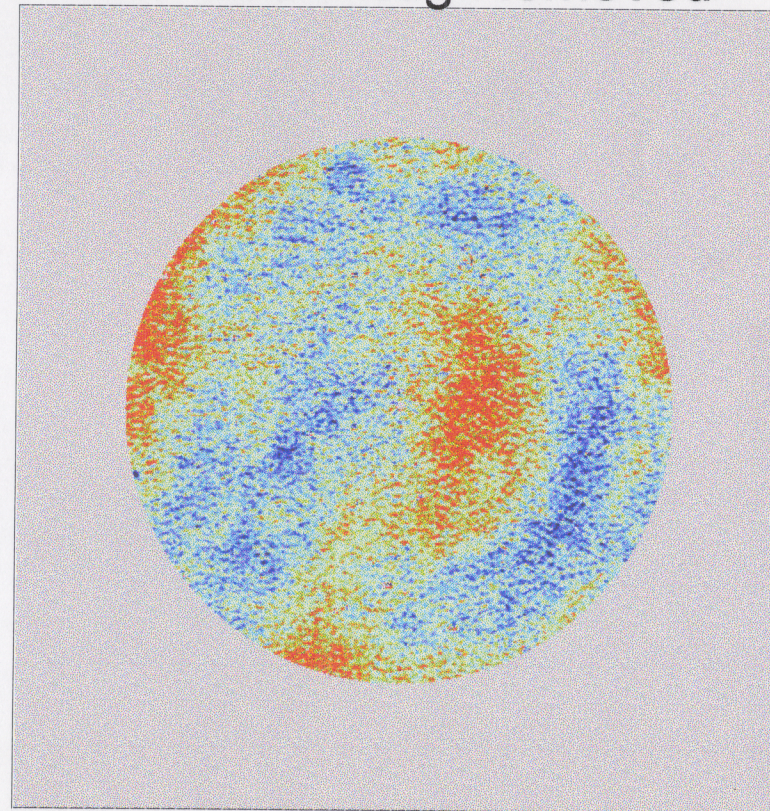
PV: 6.5 nm

RMS: 0.5 nm

Tilt Removed



Tilt/Power/Astig Removed



RM41A3

Time: 23:19

Date: 10/21/97

RMS: 0.373nm

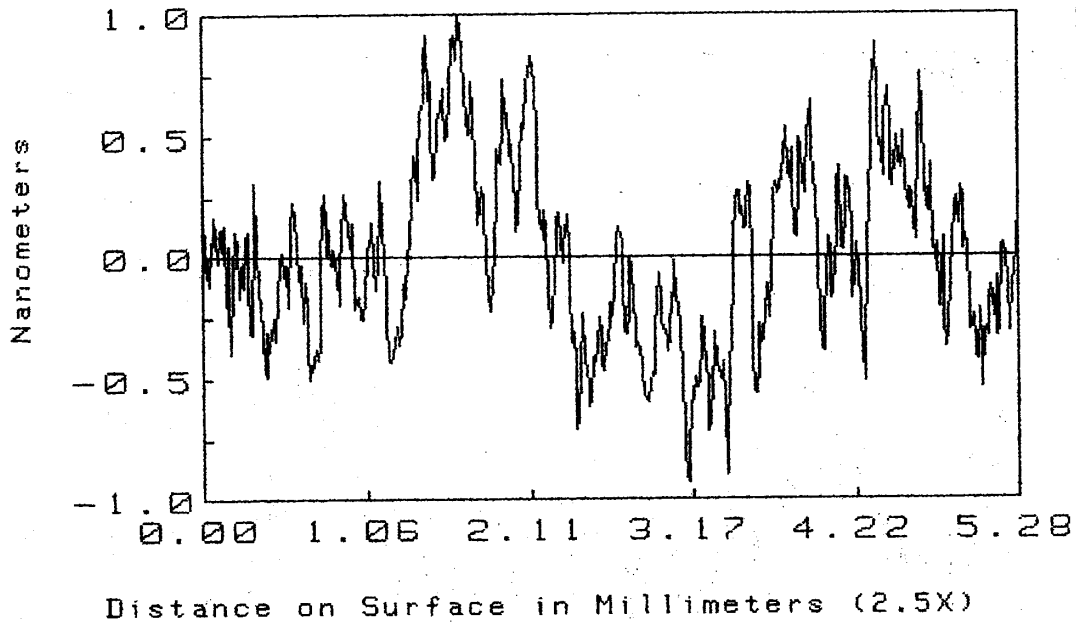
PV: 2.10nm

RA: 0.304nm

Ref. Subtracted

RC: 9361 m

PROFILE



T2RM041A.ASC

WYKO

Attach. 3

RM41B3

Time: 23:23

Date: 10/21/97

RMS: 0.364nm

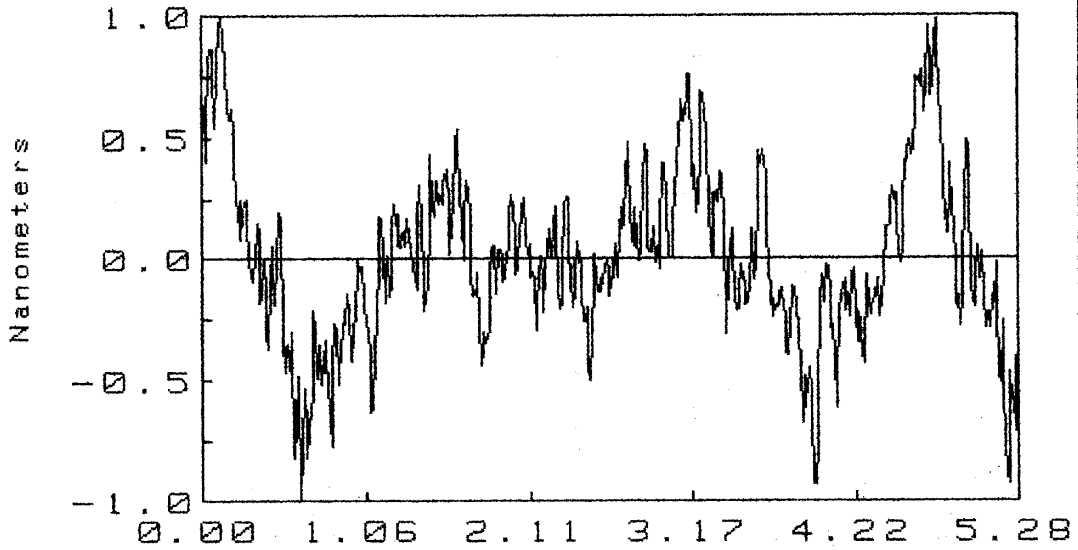
PV: 2.26nm

RA: 0.280nm

Ref. Subtracted

RC: -132 km

PROFILE



Distance on Surface in Millimeters (2.5X)

T2RM041B.ASC

WYKO

RM41C1

Time: 23:24

Date: 10/21/97

RMS: 0.341nm

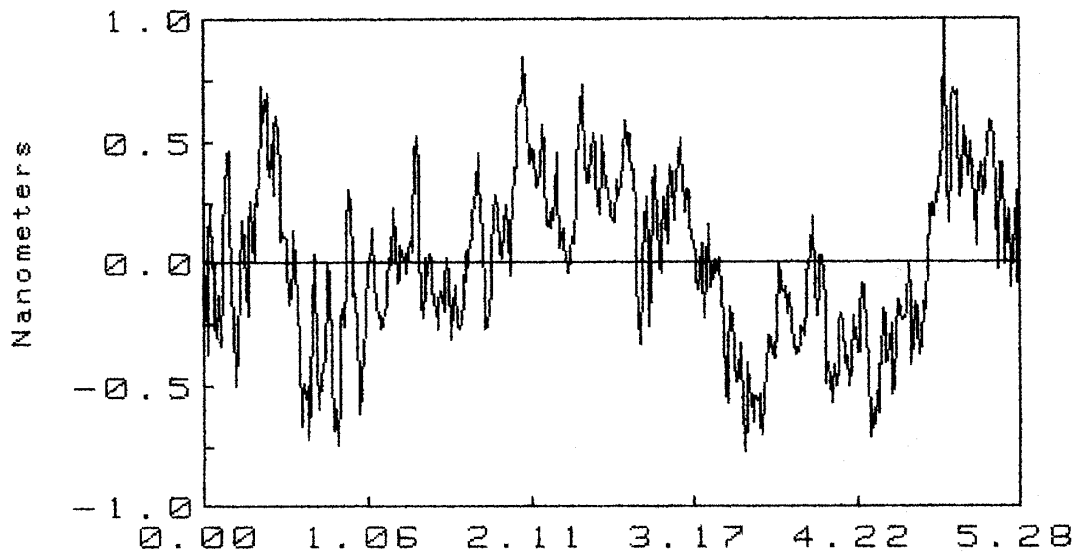
PV: 1.79nm

RA: 0.281nm

Ref. Subtracted

RC: 5303 m

PROFILE



Distance on Surface in Millimeters (2.5X)

T2RM041C.ASC

WYKO

RM41A4

Time: 17:14

Date: 10/23/97

RMS: 0.210nm

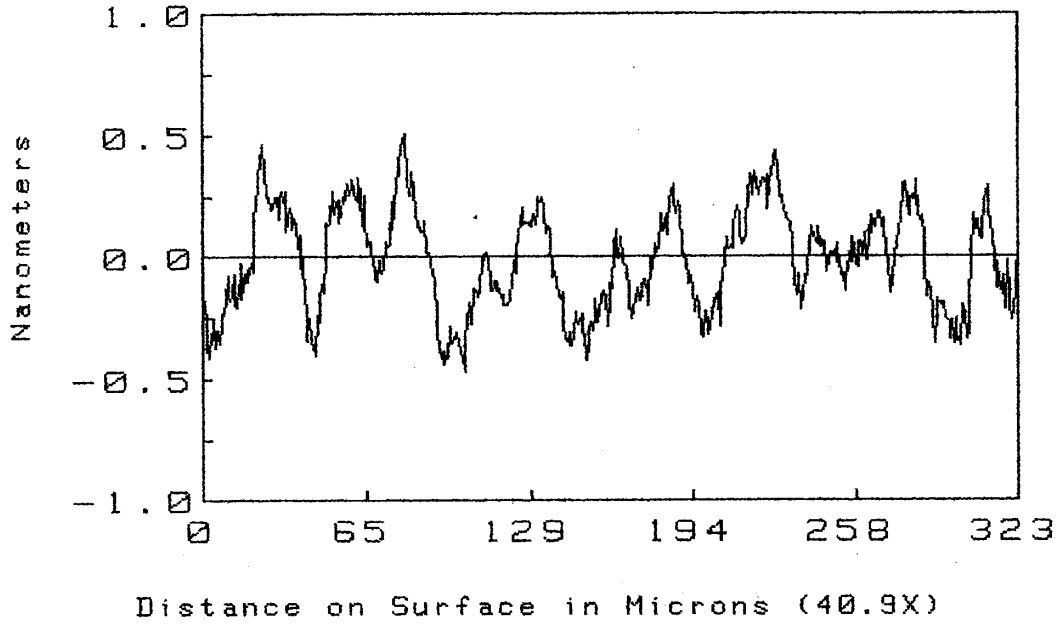
PV: 0.990nm

RA: 0.178nm

Ref. Subtracted

RC: -103 m

PROFILE



T4RM041A.ASC

WYKO

RM41B4

Time: 17:20

Date: 10/23/97

RMS: 0.224nm

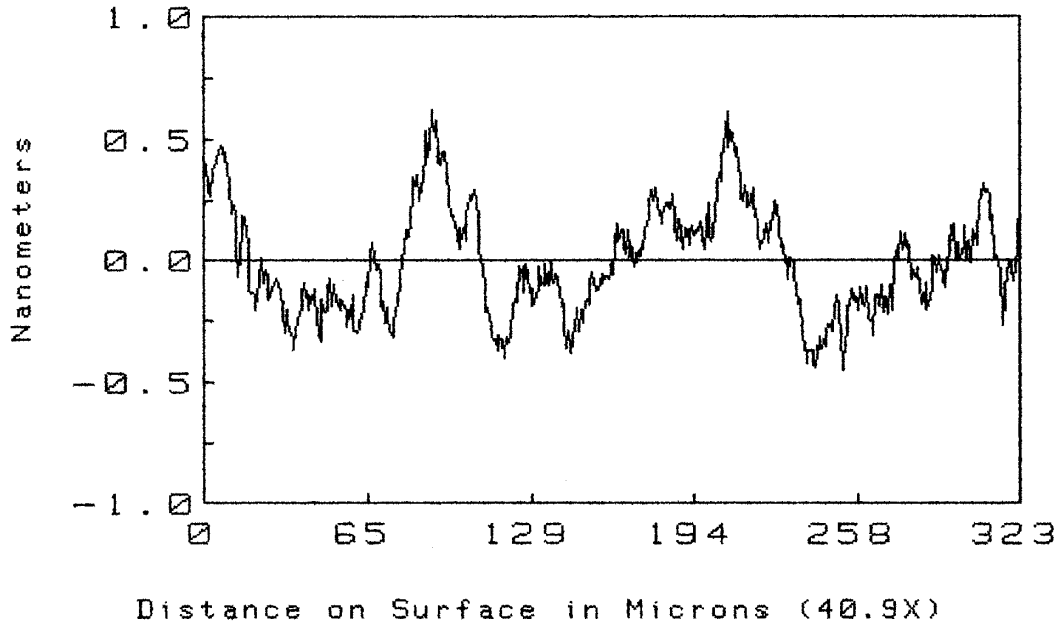
PV: 1.07nm

RA: 0.185nm

Ref. Subtracted

RC: -12.6 m

PROFILE



T4RM041B.ASC WYKO

RM41C4

Time: 17:26

Date: 10/23/97

RMS: 0.236nm

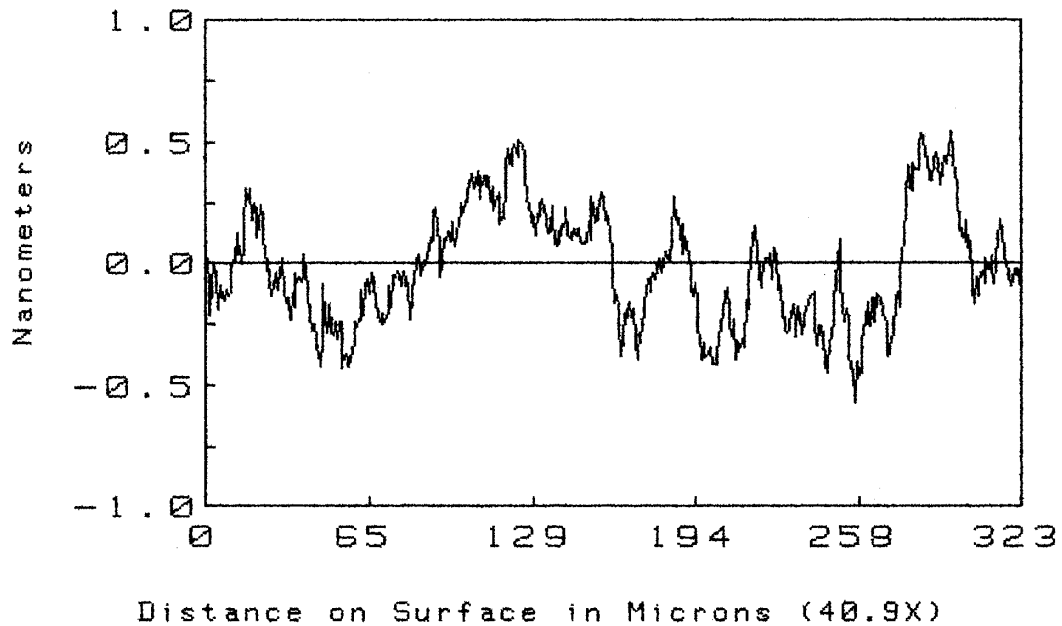
PV: 1.14nm

RA: 0.195nm

Ref. Subtracted

RC: -37.2 m

PROFILE



T4RM041C.ASC WYKO

RM42A1

Time: 3:01

Date: 10/22/97

RMS: 0.258nm

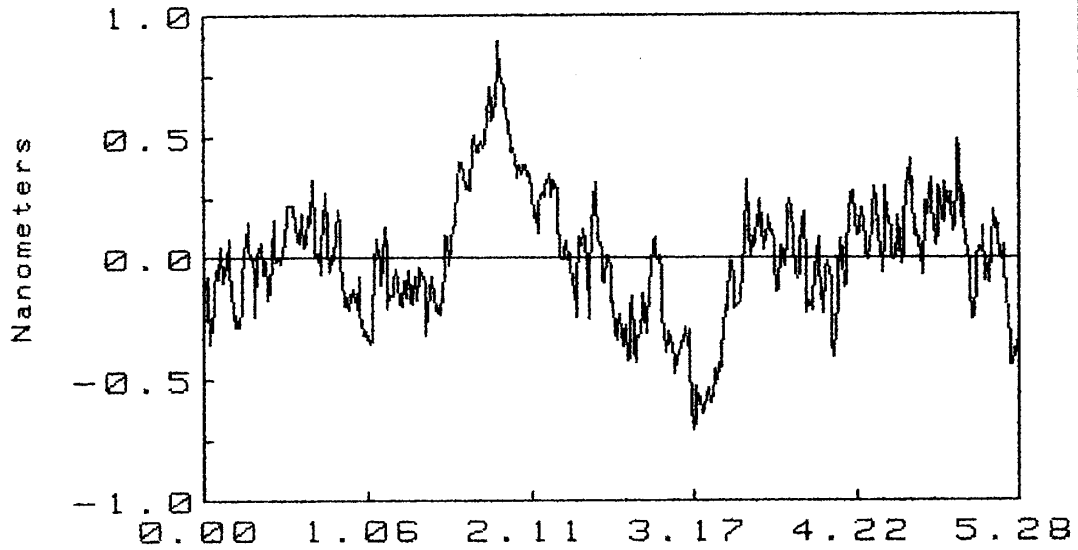
PV: 1.61nm

RA: 0.201nm

Ref. Subtracted

RC: 9404 m

PROFILE



Distance on Surface in Millimeters (2.5X)

T2RM042A.ASC

WYKO

Attach. 4

RM42B5

Time: 11:25

Date: 10/23/97

RMS: 0.138nm

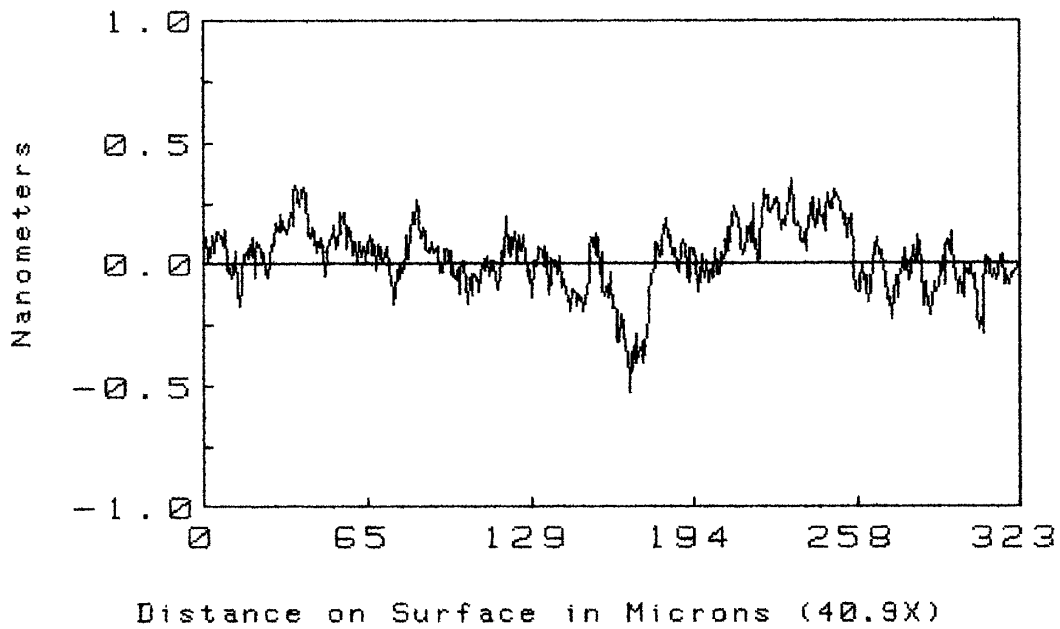
PROFILE

PV: 0.883nm

RA: 0.107nm

Ref. Subtracted

RC: -42.7 m



T4RM042B.ASC

WYKO

RM42C6

Time: 11:33

Date: 10/23/97

RMS: 0.138nm

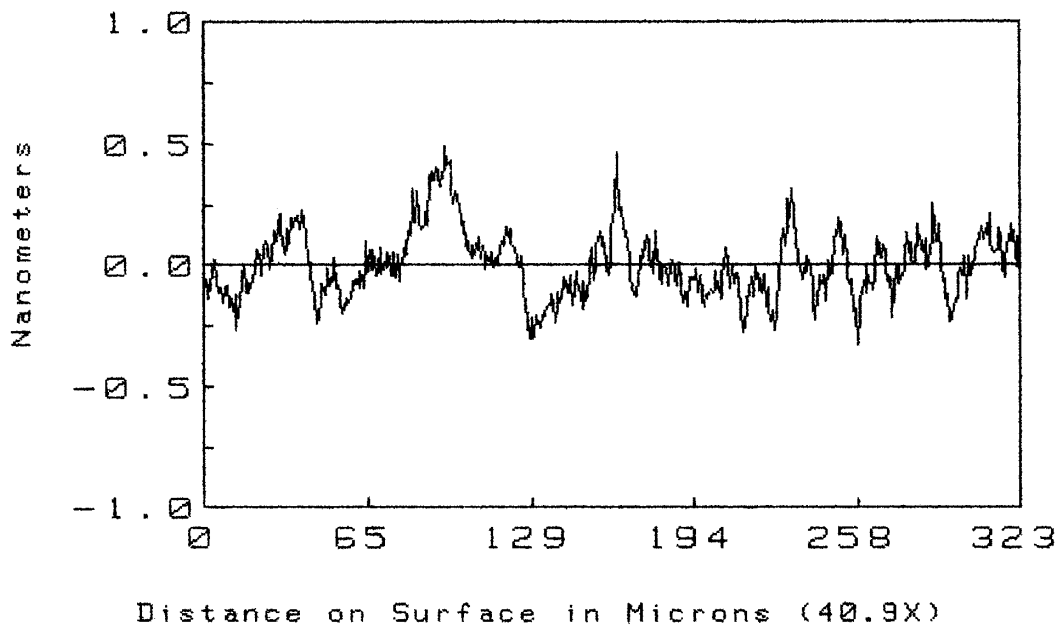
PROFILE

PV: 0.832nm

RA: 0.108nm

Ref. Subtracted

RC: -21.3 m



T4RM042C.ASC

WYKO

RM42B3

Time: 3:07

Date: 10/22/97

RMS: 0.271nm

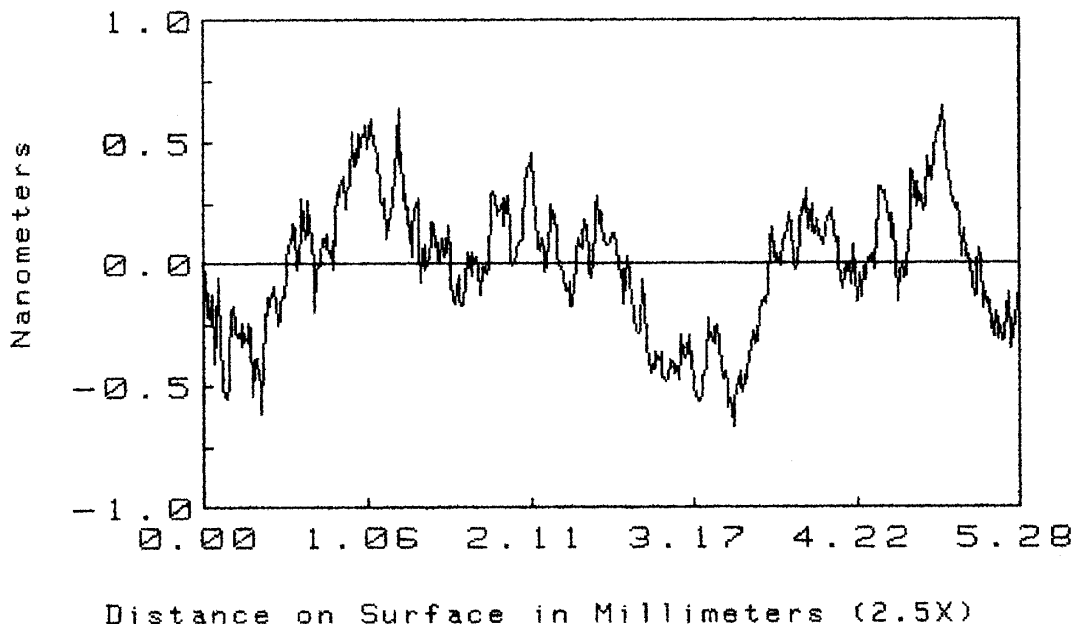
PV: 1.33nm

RA: 0.218nm

Ref. Subtracted

RC: 509 km

PROFILE



T2RM042B.ASC WYKO

RM42C1

Time: 3:08

Date: 10/22/97

RMS: 0.248nm

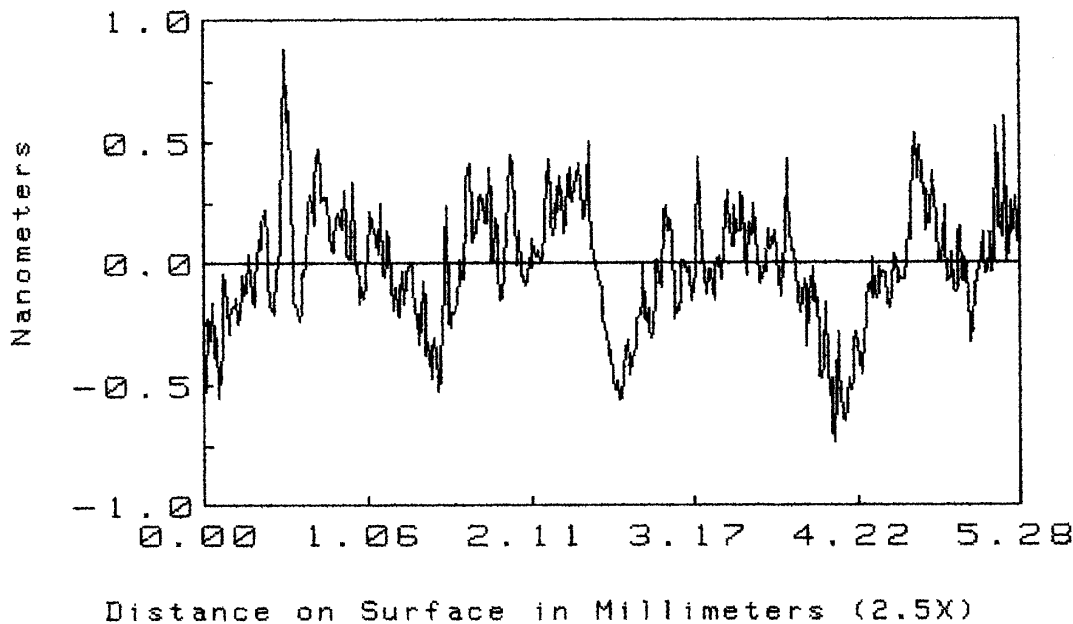
PV: 1.62nm

RA: 0.195nm

Ref. Subtracted

RC: 6828 m

PROFILE



T2RM042C.ASC WYKO

RM42A5

Time: 10:44

Date: 10/23/97

RMS: 0.149nm

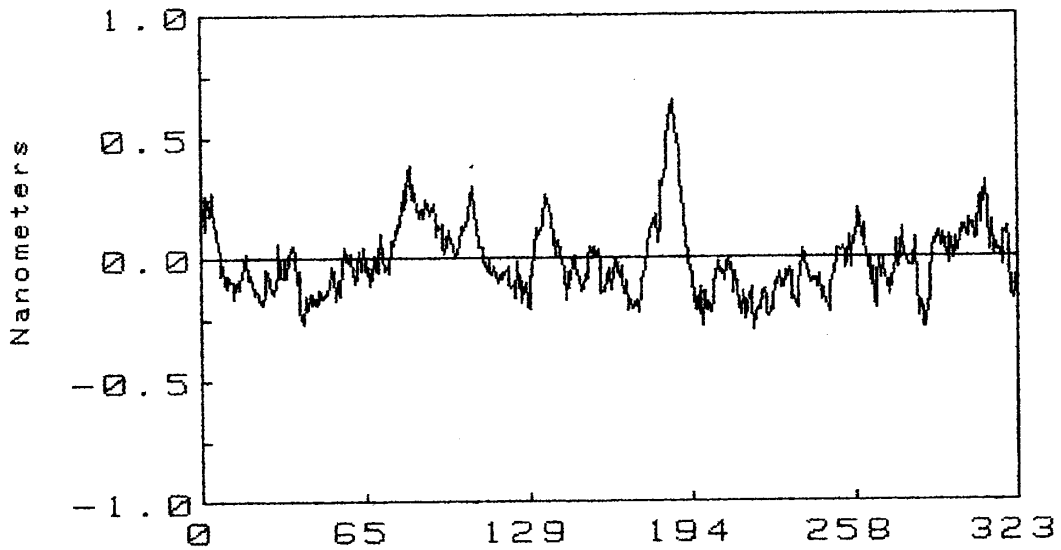
PV: 0.983nm

RA: 0.114nm

Ref. Subtracted

RC: -20.3 m

PROFILE



Distance on Surface in Microns (40.9X)

T4RM042A.ASC

WYKO