Cryogenic Test Results of POCO SiC Mirror

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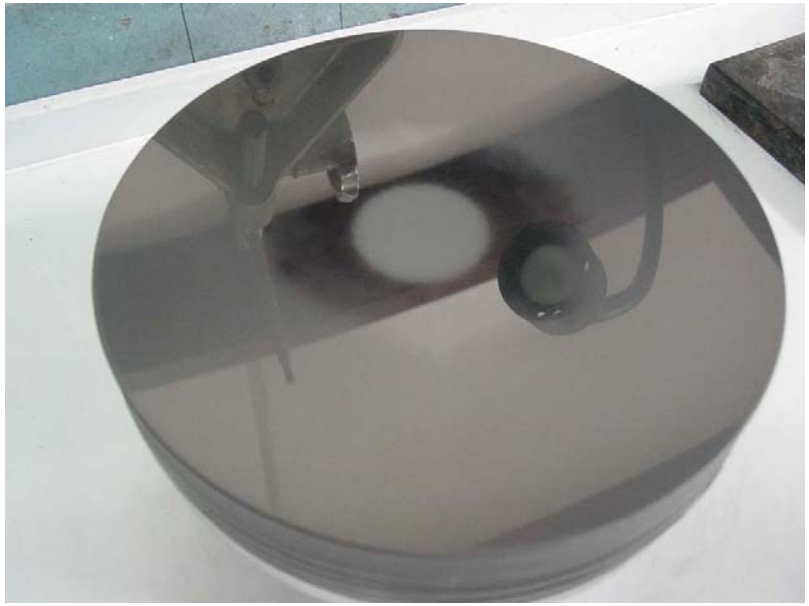
Test Article

POCO Graphite SuperSiC® (Silicon Carbide) mirror:

- Diameter: 0.25m (circular)
- Radius-of-curvature: ~ 3.0m, spherical, (R/12)
- Face sheet: ~1.7mm thick after polish by Dallas Optical Systems (CVD SiC cladding).
- Rib structure: 35mm thick/tall (minor ribs 5mm tall), 25mm inscribed diameter cells, with 1.2mm thick ribs & 1.4mm rib-to-face fillet radii.
- Areal density: 16 kg/m^2

- Additional information can be found in presentations by POCO Graphite: http://optics.nasa.gov/tech_days/tech_days_2003/docs/44POCOMSFC0.25mirror.pdf ; and at www.poco.com.

POCO SiC

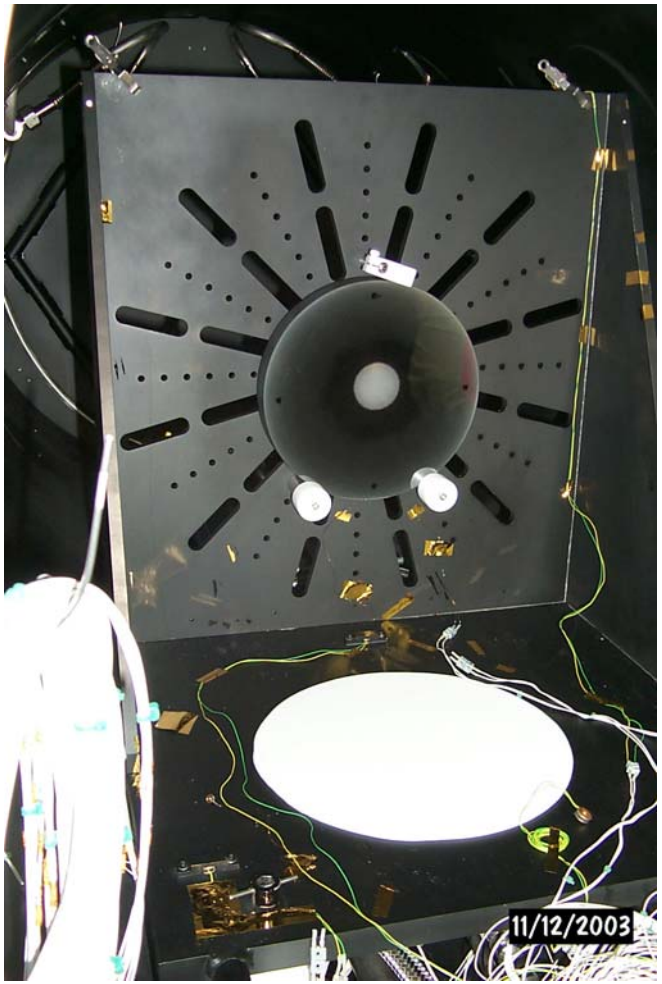


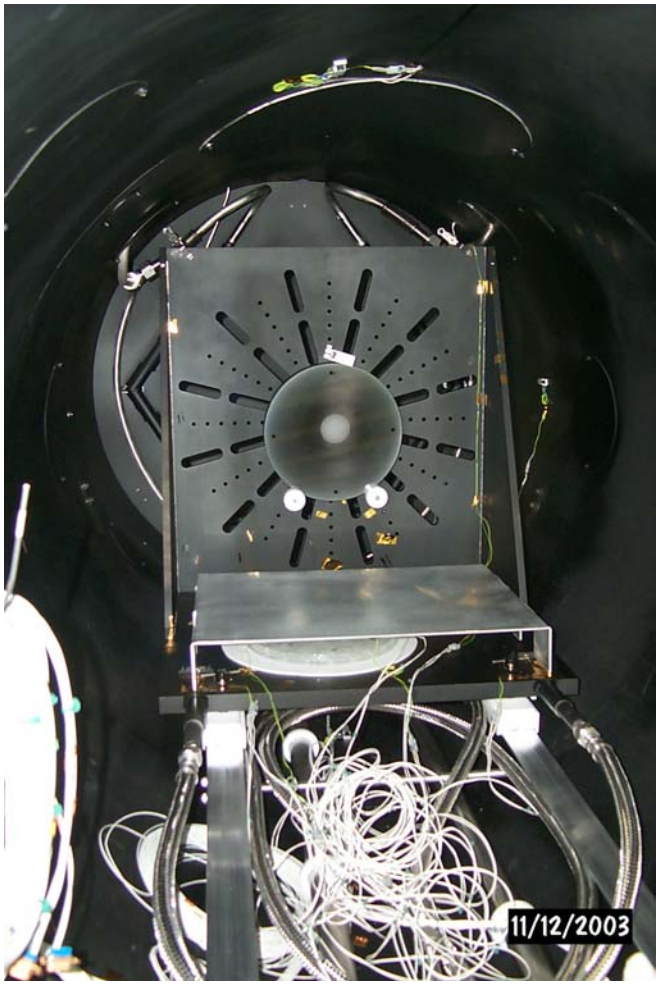
Central area of SiC cladding inadvertently polished thru.

Test Set-Up

- Mounting:
  - Mirror rested on two stainless steel posts with Teflon caps.
  - Teflon safety bumper located near top of mirror to prevent falling forward. Minimal contact between mirror and safety bumper, if any.
  - Interface plate to aluminum test stand (with actively-cooled base).
  - 2 silicon temperature diodes attached to mirror back ribs with Kapton tape: 1 near center & 1 near bottom.
- Fiducials:
  - 4 filled circles (6.5mm diameter) at 90° intervals near edge.
- Tested 1 time (2 cryo cycles), in small chamber, using IPI/OptiCode.

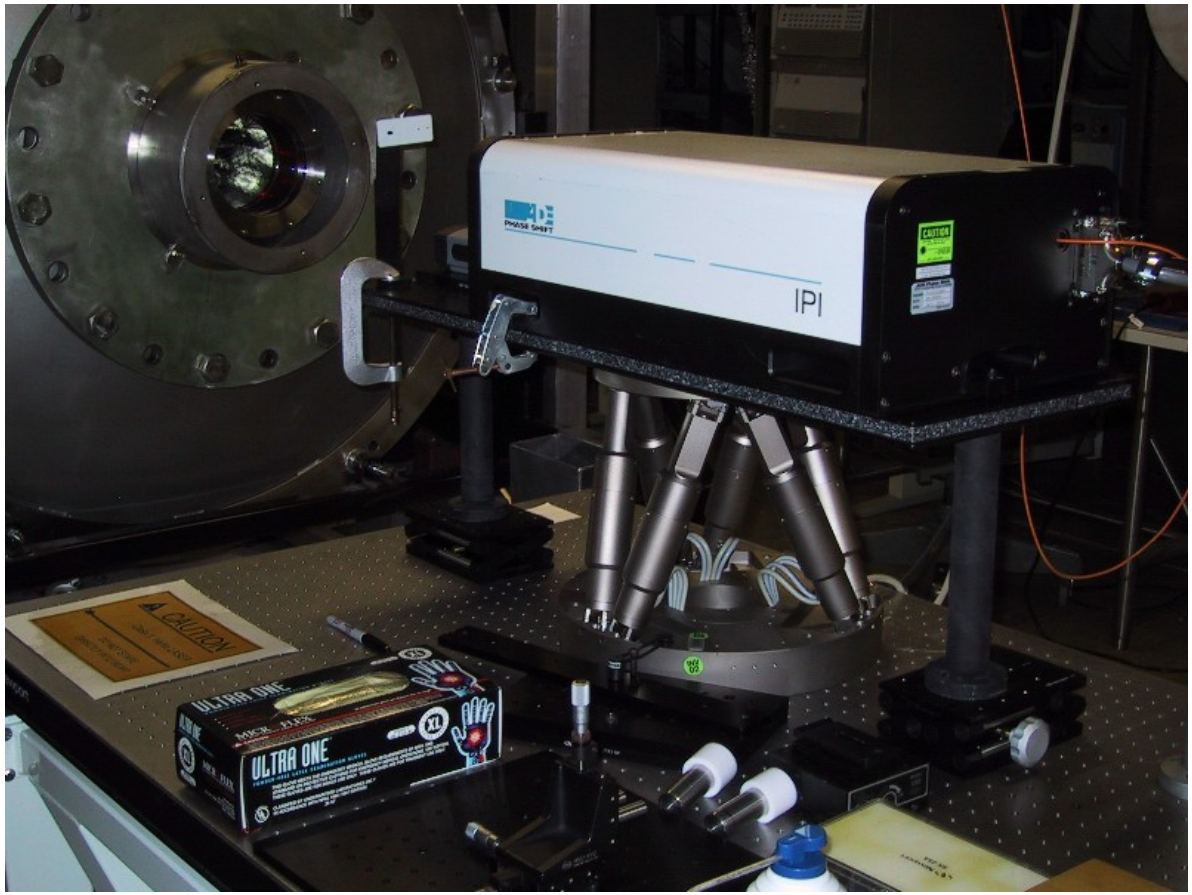
Mirror in Chamber





POCO mirror rested on 2 posts with Teflon bumper at top to prevent mirror falling forward during test.

Optical Test System



IPI interferometer with f/8 diverger atop hexapod looking thru 25.4mm thick BK7 window into chamber.

Test Objectives

- Test Objectives:
  - Primary: Measure surface figure error at ambient (~290K) & cryo (~30K) at least twice for repeatability.
  - Secondary: Measure surface figure error at other temperatures of interest (especially 200, 100, 65, & 55K).
  - Secondary: Check test article survival at 25K.
- Surface Figure Error Measurement Uncertainty:
  - Absolute uncertainty, without subtraction of instrumental error, estimated at ±7nm-rms.
  - Uncertainty in any difference between two measurements estimated at only ±3nm-rms.
  - Both absolute & difference uncertainties for residual results (FRINGE Zernikes removed) estimated at ±2nm-rms.
  - Effects of thermal gradients in mirror and/or differences in such gradients between any two measurements not accounted for in estimates above.

Measurement Timeline

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
11/16/03	11/17/03	11/18/03	11/19/03 **Ambient pressure, 292K**	11/20/03 **1st cycle Vac, 290K**	11/21/03 **1st cycle Vac, 197K**	11/22/03 **1st cycle Vac, 99K**
11/23/03	11/24/03 **1st cycle Vac, 64K, 51K**	11/25/03 **1st cycle Vac, 30K**	11/26/03 **1st cycle Vac, 23K**	11/27/03	11/28/03	11/29/03
11/30/03	12/1/03 **2nd cycle Vac, 291K**	12/2/03 **2nd cycle Vac, 197K**	12/3/03 **2nd cycle Vac, 97K**	12/4/03 **2nd cycle Vac, 50K**	12/5/03 **2nd cycle Vac, 30K**	12/6/03
12/7/03	12/8/03 **2nd cycle Vac, 290K; Ambient pressure, 289K**	12/9/03	12/10/03	12/11/03	12/12/03	12/13/03

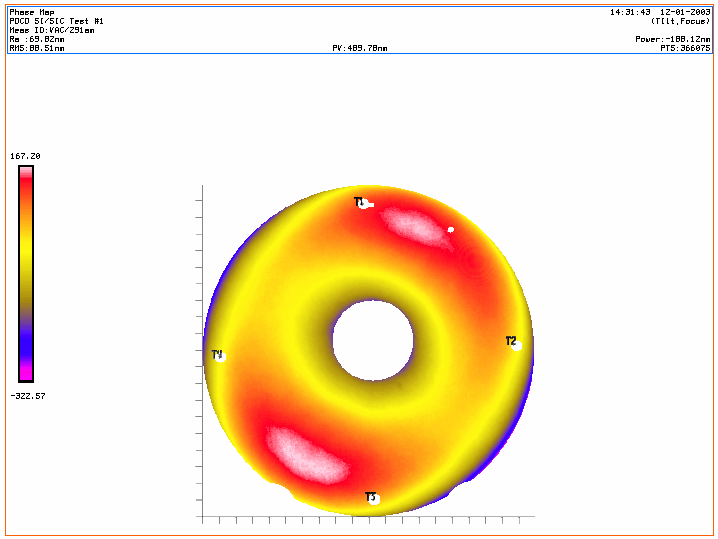
Definitions

- Total Figure Error: surface error map with piston, tilt, & focus removed.

- Residual Figure Error: total figure error minus Zernike fit of 37 Fringe Zernike terms.

291K (2nd cycle)

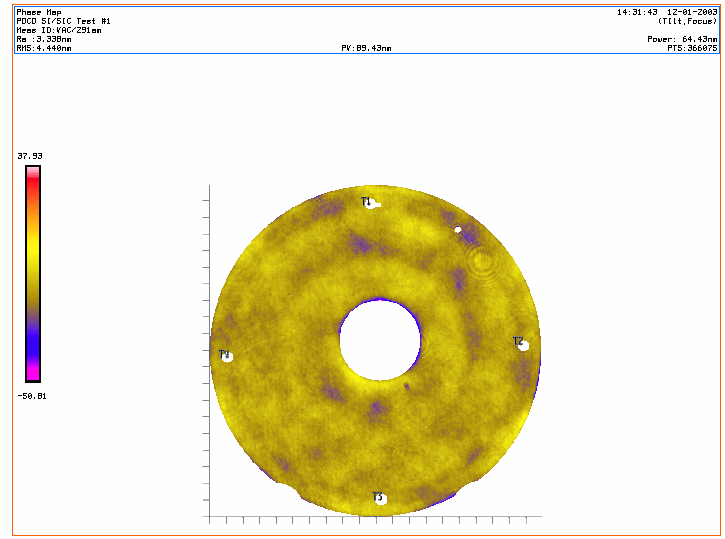
Total Figure Error



Test ID: POCO SI/SIC Test #1		Date: 12-01-2003 14:31:43
Meas ID: VAC/291am	ADE/PHASE SHIFT	Wedge: Surface
Customer: POCO	OptiCode/IPI - Instantaneous Phase Software	Polarity: +
Operator: XRCF	Version 4.42 (c) 1995-2002	
Terms Subtracted: Tilt Focus		

PV = 490nm
RMS = 88.5nm

Residual Figure Error

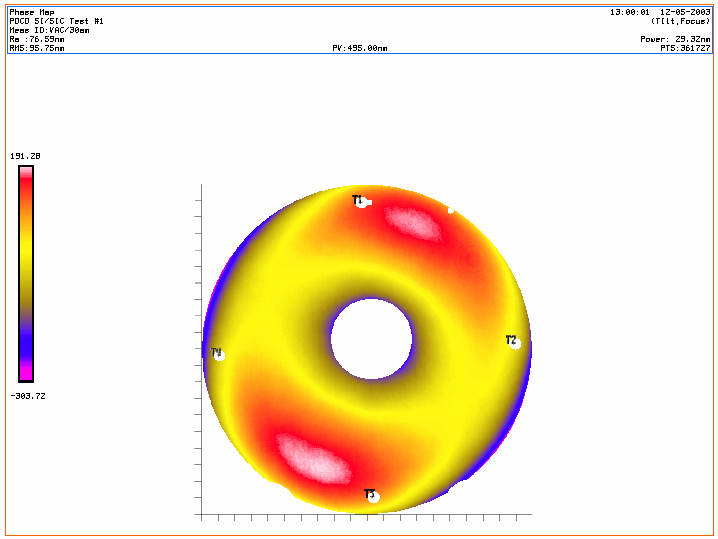


Test ID: POCO SI/SIC Test #1		Date: 12-01-2003 14:31:43
Meas ID: VAC/291am	ADE/PHASE SHIFT	Wedge: Surface
Customer: POCO	OptiCode/IPI - Instantaneous Phase Software	Polarity: +
Operator: XRCF	Version 4.42 (c) 1995-2002	
Terms Subtracted: Tilt Focus		

PV = 89nm
RMS = 4.4nm

30K (2nd cycle)

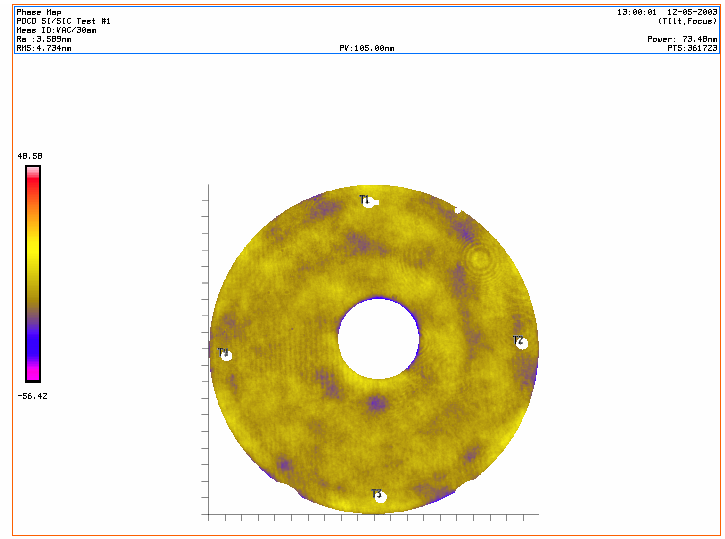
Total Figure Error



Test ID: POCO SiC/SiC Test #1		Date: 12-05-2003 13:00:01
Meas ID: VAC/30am	ADE/PHASE SHIFT	Wedge: Surface
Customer: POCO	OptiCode/IPI - Instantaneous Phase Software	Polarity: +
Operator: XRCF	Version 4.42 (c) 1995-2002	
Terms Subtracted: Tilt Focus		

PV = 495nm
RMS = 95.8nm

Residual Figure Error

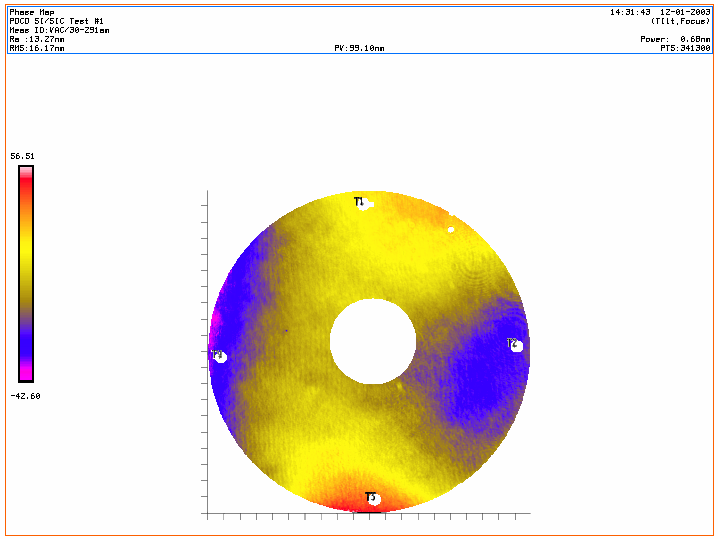


Test ID: POCO SiC/SiC Test #1		Date: 12-05-2003 13:00:01
Meas ID: VAC/30am	ADE/PHASE SHIFT	Wedge: Surface
Customer: POCO	OptiCode/IPI - Instantaneous Phase Software	Polarity: +
Operator: XRCF	Version 4.42 (c) 1995-2002	
Terms Subtracted: Tilt Focus		

PV = 105nm
RMS = 4.7nm

Cryo Deformation
30-291K (2nd cycle)

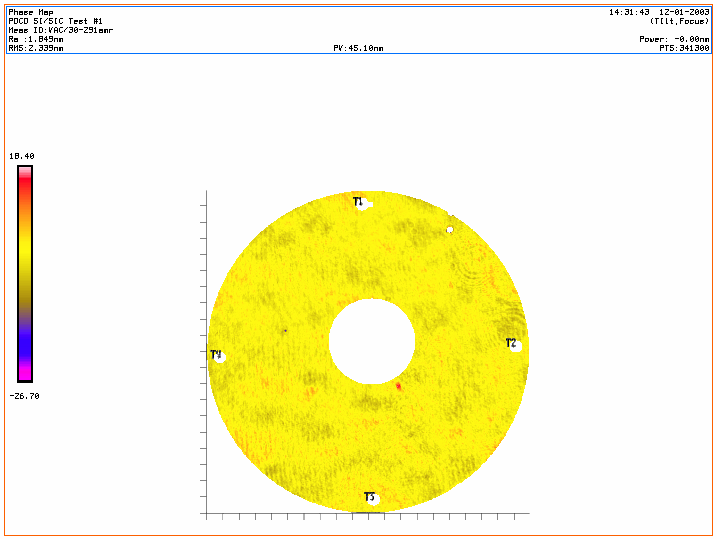
Total Figure Error



Test ID: POCO SI/SIC Test #1		Date: 12-01-2003 14:31:43
Meas ID: VAC/30-291am	ADE/PHASE SHIFT	Wedge: Surface
Customer: POCO	OptiCode/IPI - Instantaneous Phase Software	Polarity: +
Operator: XRCF	Version 4.42 (c) 1995-2002	
Terms Subtracted: Tilt Focus		

PV = 99nm
RMS = 16.2nm

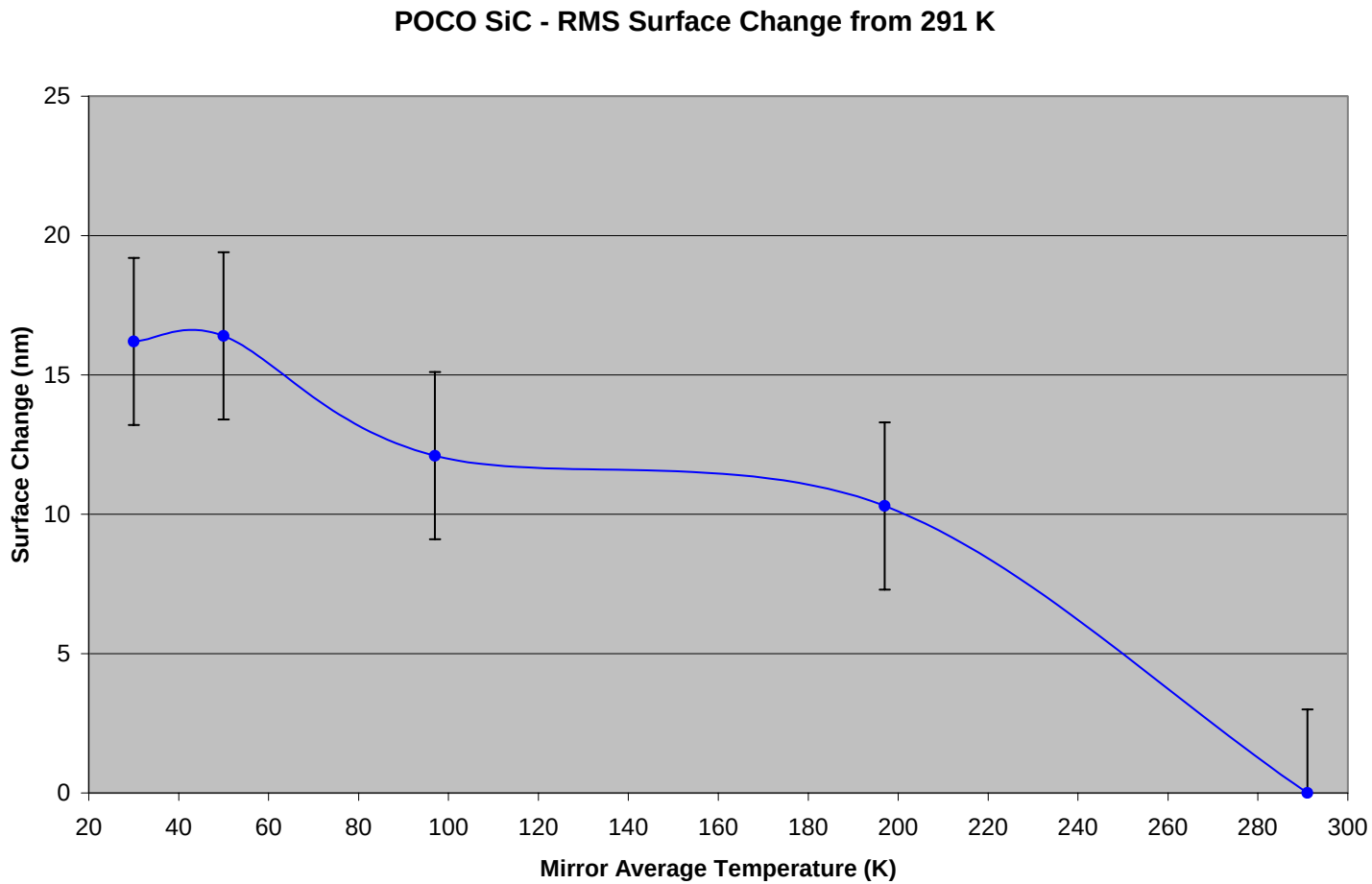
Residual Figure Error



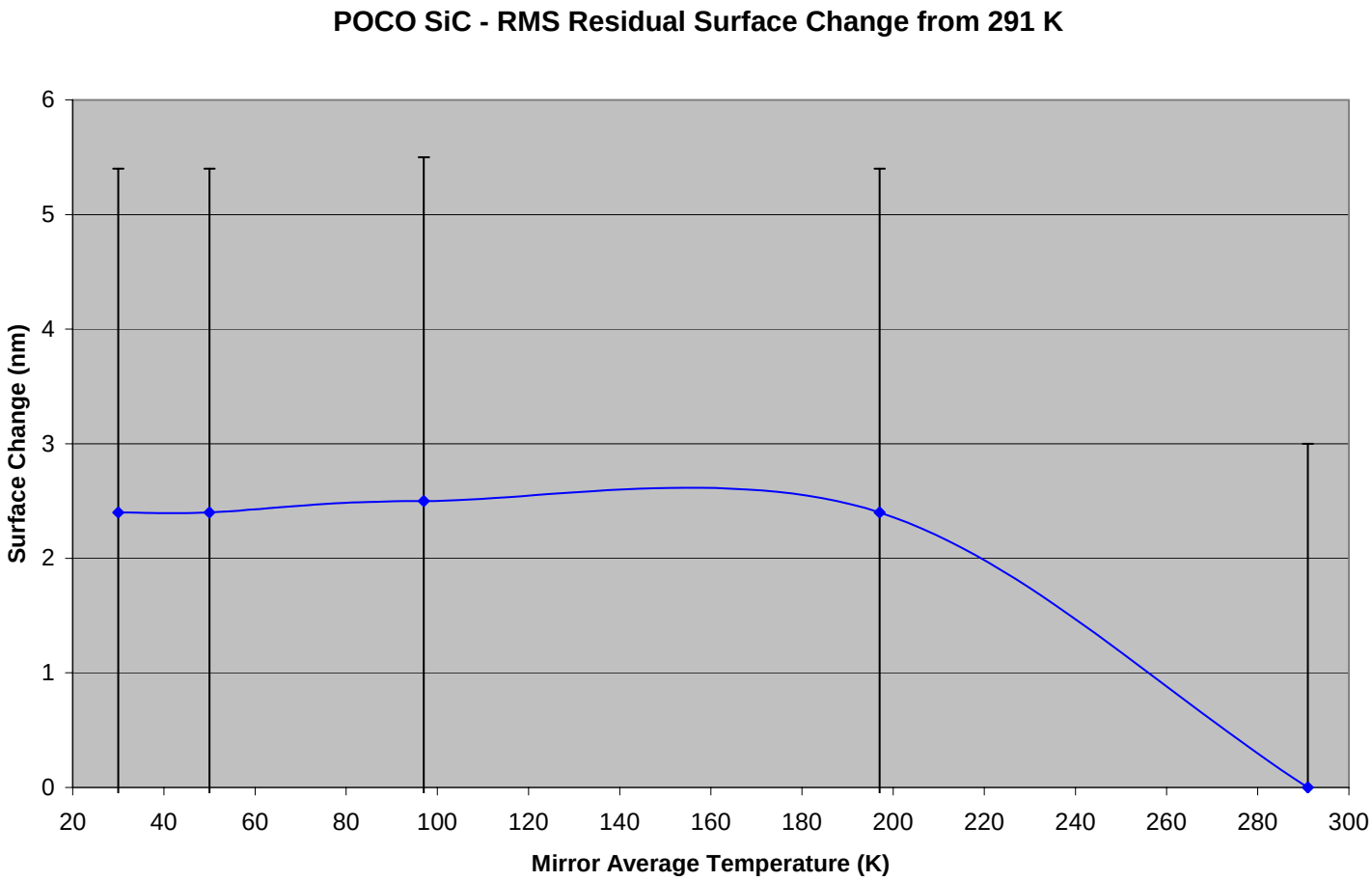
Test ID: POCO SI/SIC Test #1		Date: 12-01-2003 14:31:43
Meas ID: VAC/30-291amr	ADE/PHASE SHIFT	Wedge: Surface
Customer: POCO	OptiCode/IPI - Instantaneous Phase Software	Polarity: +
Operator: XRCF	Version 4.42 (c) 1995-2002	
Terms Subtracted: Tilt Focus		

PV = 45nm
RMS = 2.3nm

RMS Total Figure Change vs Temperature

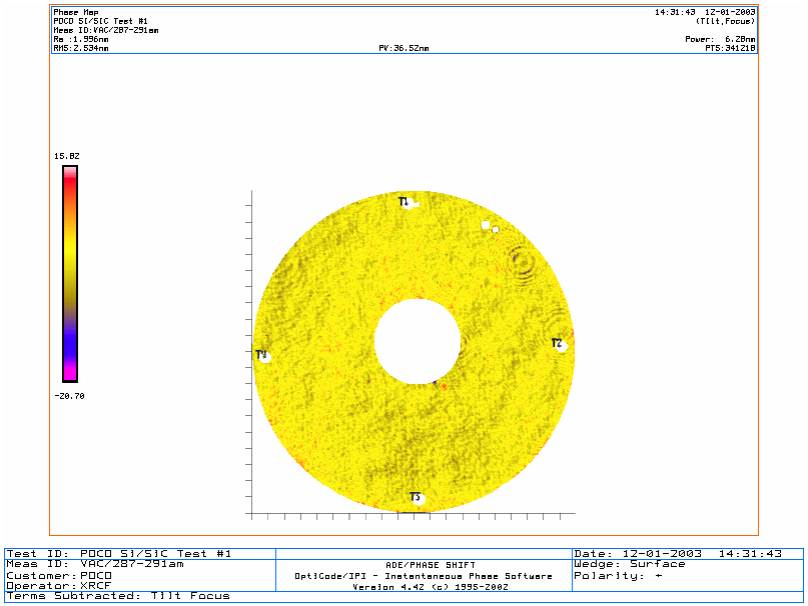


RMS Residual Figure Change vs Temperature



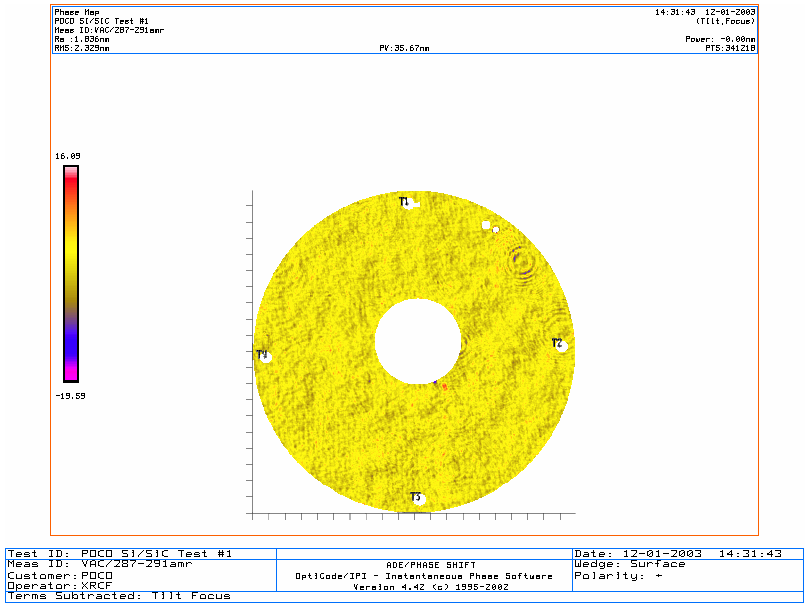
Change at Ambient, 287-291K (2nd cycle)

Total Figure Error



PV = 37nm
RMS = 2.5nm

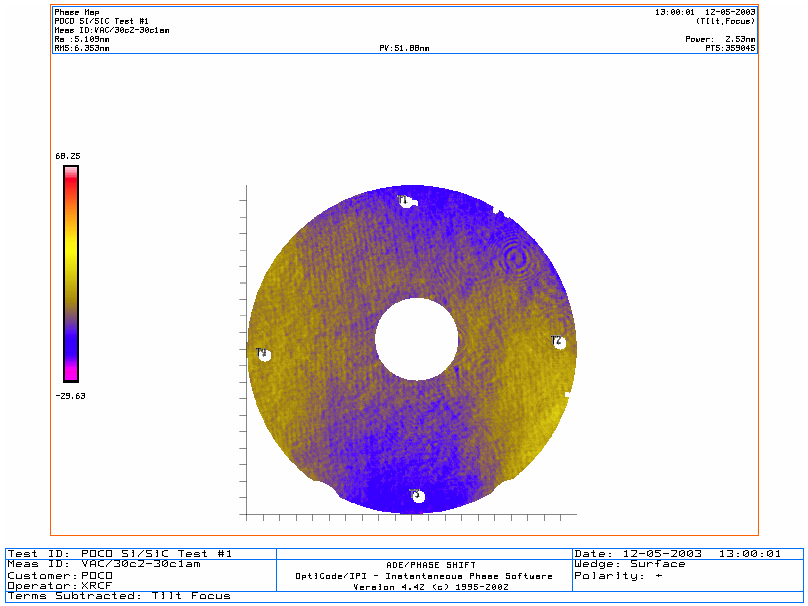
Residual Figure Error



PV = 36nm
RMS = 2.3nm

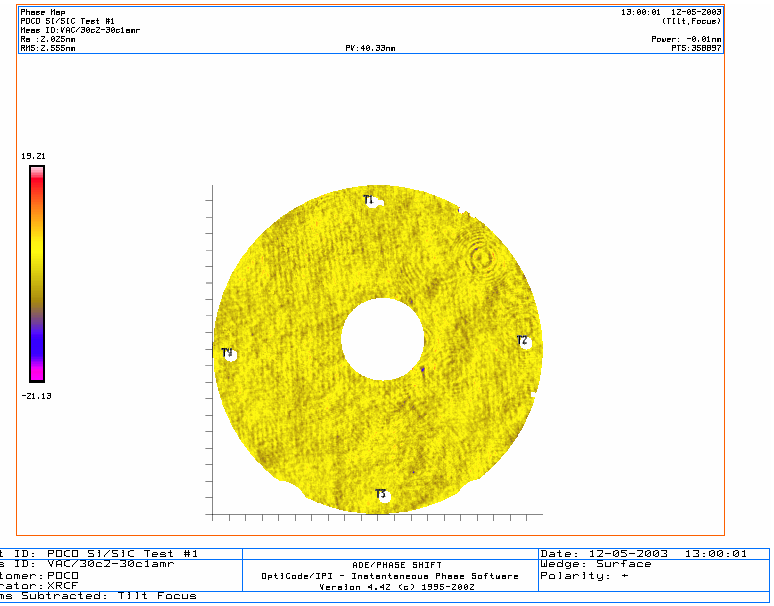
Change at Cryo, 30-30K

Total Figure delta



PV = 52nm
RMS = 6.4nm

Residual Figure delta



PV = 40nm
RMS = 2.6nm

POCO SiC Summary

- Figure changes level off around 130K, corresponding to SiC strain.
- Total cryo deformation of 16nm-rms; mostly astigmatism.
- Residual surface figure change of 2nm-rms; below measurement uncertainty; no cryo-quilting of ribs visible.
- Figure change repeatable for both cryo cycles.
- No change in 291K figure observed due to cryo-cycle.