Core Optics Components: Requirements and Status

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Requirements / Status Overview

Table 1: COC Requirements and Status

Parameter	Requirement	Status	Interferometer Coupling
Surface Figure Surface Error (Power, Astigmatism removed)	< 20 nm P-V < 1 nm rms over 8 cm diameter	< 10 nm P-V < 1 nm rms over 20 cm diameter	Increased Power at Dark Port (Shot Noise)
Coating Uniformity	consistent with above	5 - 10 nm P-V < 1 nm rms over 8 cm diameter	as above

Requirements Overview (cont.)

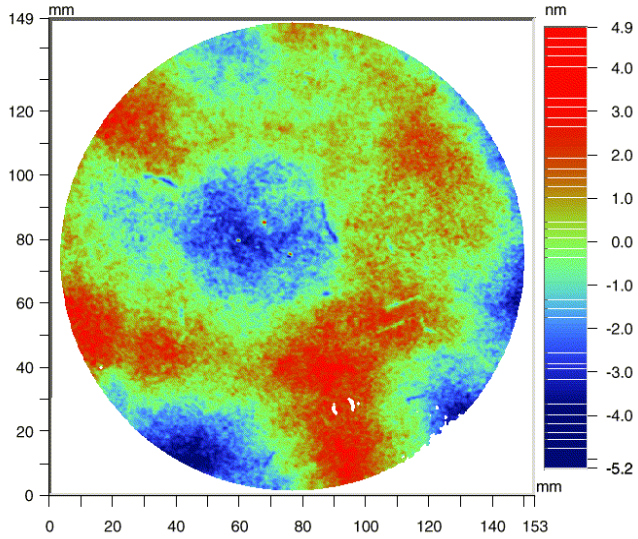
Parameter	Requirement	Status	Interferometer Coupling
Scatter Losses µroughness + defects	< 50 ppm	< 20 ppm	Loss of Power in FP arms
Absorption Losses Bulk Surface (coating)	< 5 ppm / cm < 1 ppm	~ 3 ppm / cm ~ 0.5 ppm	Thermal Lensing -> Loss of Sideband Power

Metrology of Coated Optics

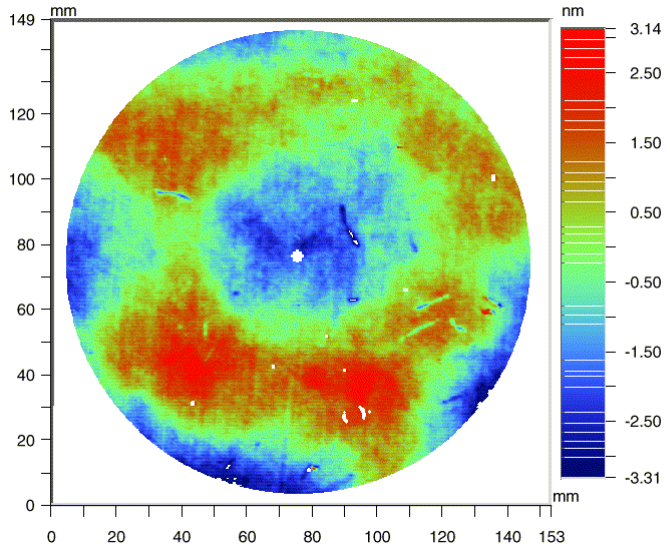
G. Billingsley, M. Hrynevych

- Phase Measuring IR interferometer operating at Caltech
- Comparison of Caltech measurements with NIST, CSIRO indicates metrology consistency at ~1 nm rms level
- QA: All Core Optics measured at Caltech before LIGO installation
- Metrology Results As Expected
  - ›› Polishing achieves 1 nm rms level
  - ›› Coating adds ~ 5 nm P-V “bowl shaping”, or ~ 3% ROC change

Caltech, CSIRO Comparison of Pathfinder Optic

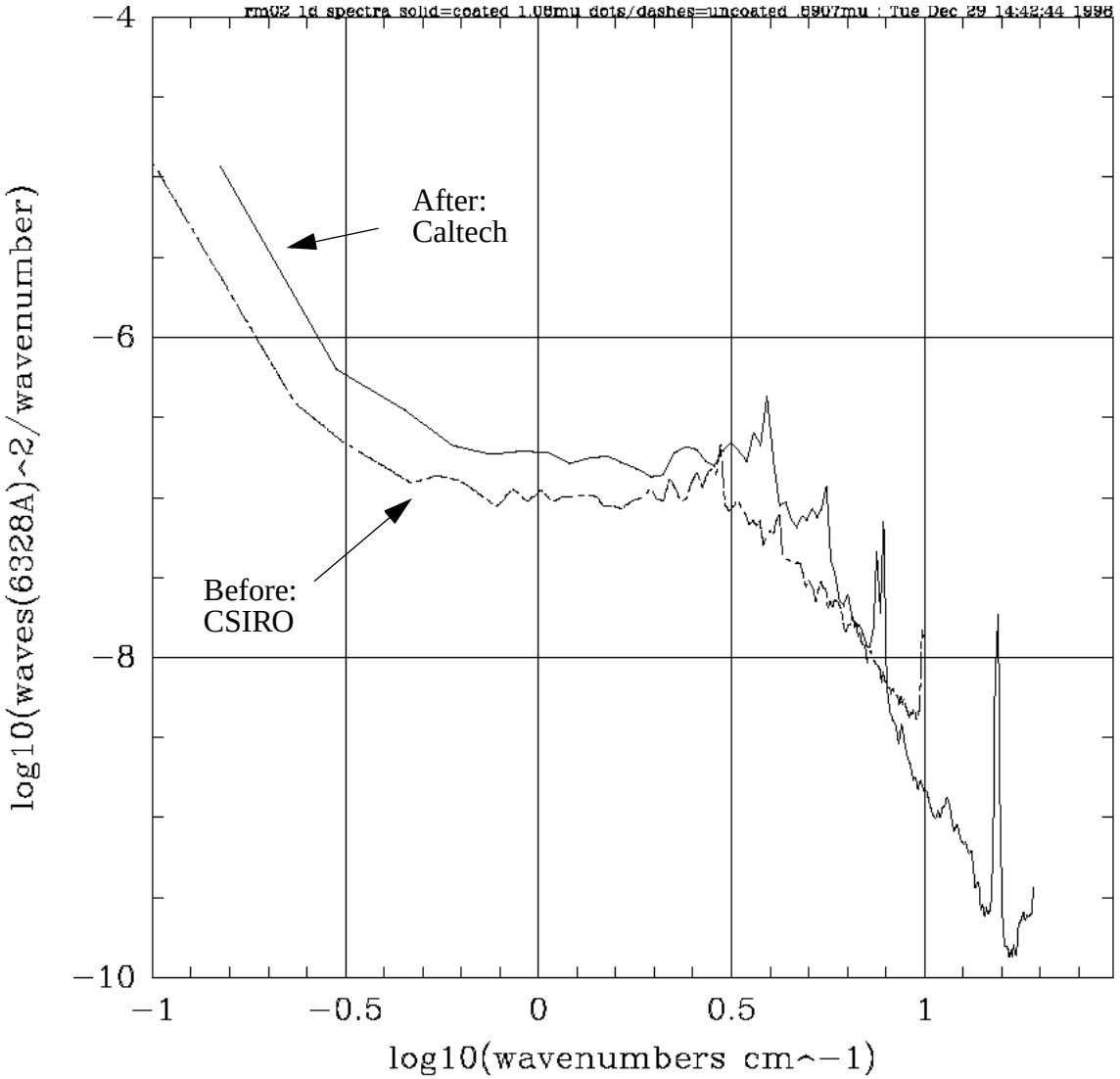


Caltech
1.5 nm rms
10.2 nm P-V



CSIRO
1.1 nm rms
6.4 nm P-V

Recycling Mirror Before and After Coating



Radii of Curvature

Table 2: Measured ROC

Optic	ROC uncoated (CSIRO)	ROC coated (Caltech)	Coating "Bowl Shaping"
RM01	15.12	14.61	7 nm
ITM01	13.38	13.23	2 nm
ITM02	13.61	13.28	5 nm
ITM03	13.41	13.07	5 nm
ITM04	13.48	13.22	4 nm

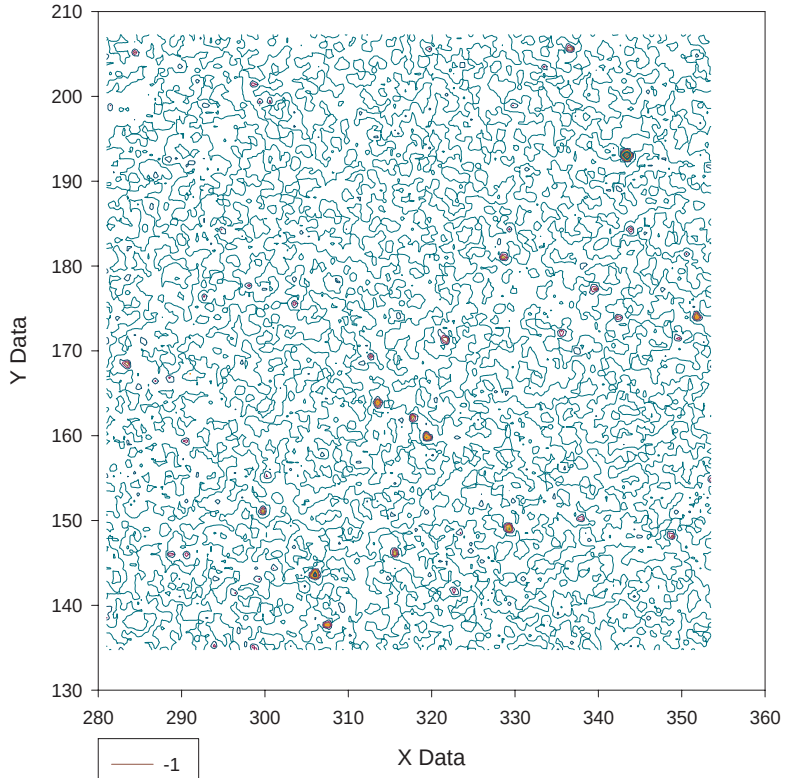
- ~ 2% accuracy (3 nm) in ROC measurements
- Measured coating curvature as expected from Pathfinder

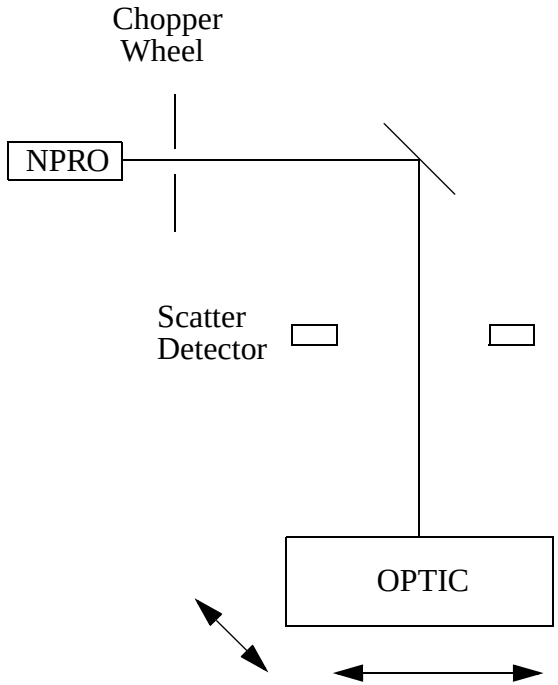
Scatter Losses

- Microroughness
  - » < 10 ppm CSIRO
  - » < 2 ppm GO
    - loss inferred from REO micromap measurement
- Surface Defects
  - » measured with Core Optics Loss Scanner
  - » < 5 ppm total

ITM Scatter Measurement

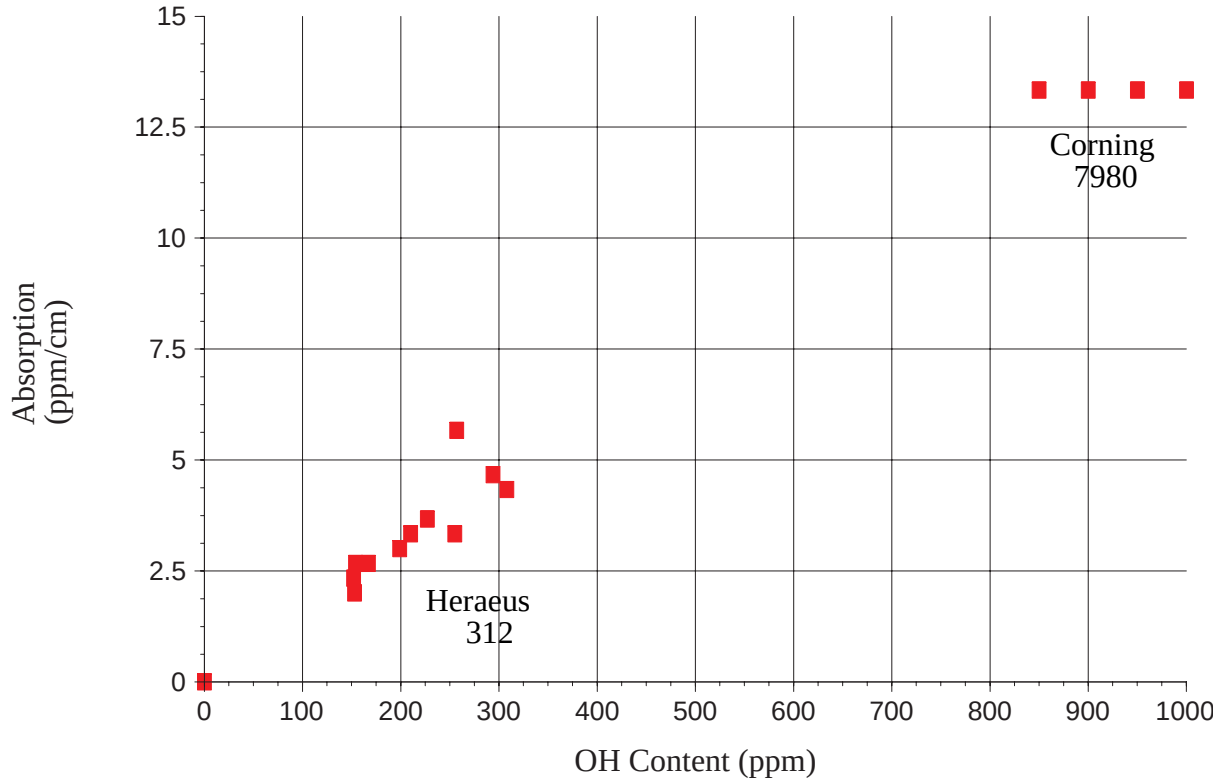
S. Bell, D. Li





- Loss from defects < 5 ppm

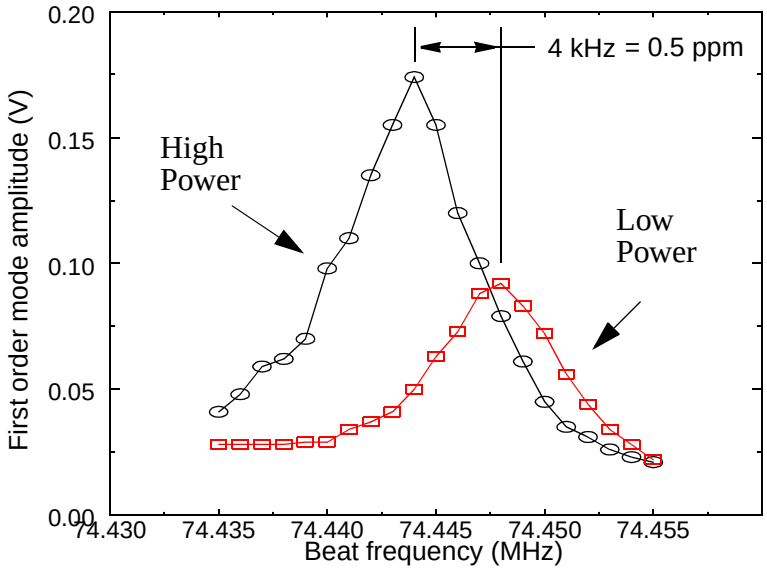
Absorption Loss : Substrate
G. Billingsley



- Absorption measured by photothermal deflection

Absorption Loss : Coating
D. Li

- Cavity mode frequency spacing depends on absorption
  - ›› Shift of frequency with stored power allows absorption to be inferred



- Absorption of REO coatings ~ 0.5 ppm
  - ››Challenge for advanced LIGO

Core Optics Cleaning Procedures
H. Armandula

- Optics cleaned with soak in hot Alcanox detergent
  - ›› Detergent removes hydrocarbon layers from surface
  - ››"Steam Test" to see if water wets the surface
- In - Situ cleaning with CO_2 Snow
  - ›› CO_2 ice particles remove particulates from surface
- Both methods qualified by cavity ringdown loss measurements

Summary

- We got glass
- We got coatings
- We know how to keep ‘em clean

- We’re ready!