

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

Requirements Overview (cont.)

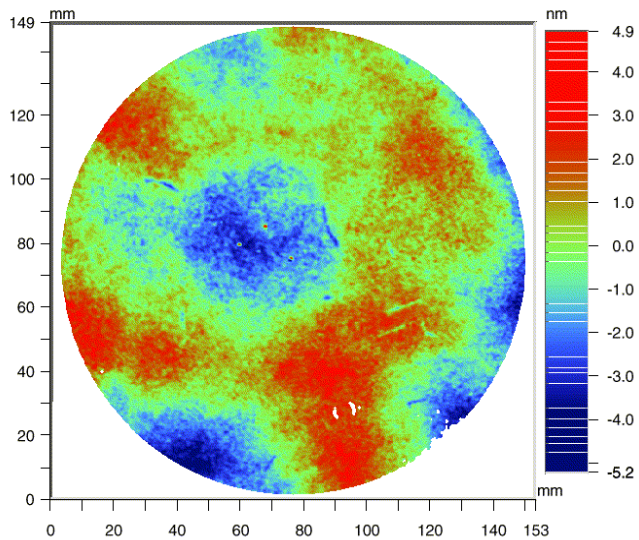
Parameter	Requirement	Status	Interferometer Coupling
Scatter Losses μroughness + defects	< 50 ppm	< 20 ppm	Loss of Power in FP arms
Absorption Losses Bulk	< 5 ppm / cm	~ 3 ppm / cm	Thermal Lensing -> Loss of Sideband Power
Surface (coating)	< 1 ppm	~ 0.5 ppm	

Metrology of Coated Optics

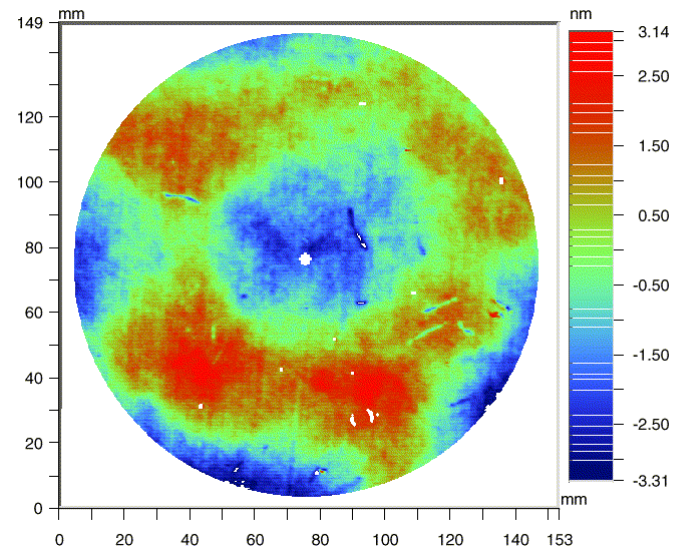
G. Billingsley, M. Hrynevych

- 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 $\sim 3\%$ ROC change

Caltech, CSIRO Comparison of Pathfinder Optic

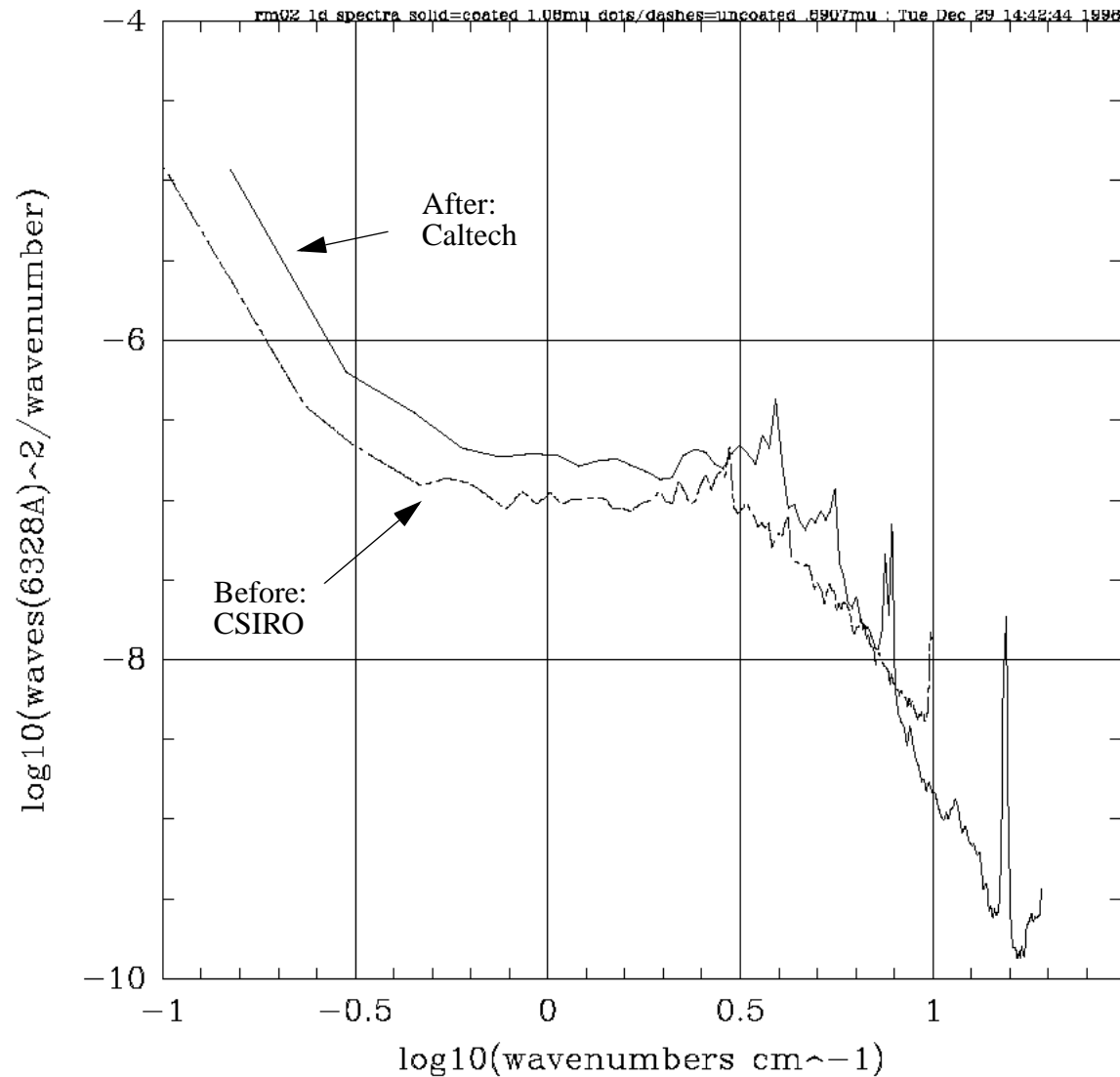


Caltech
1.5 nm rms
10.2 nm P-V



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

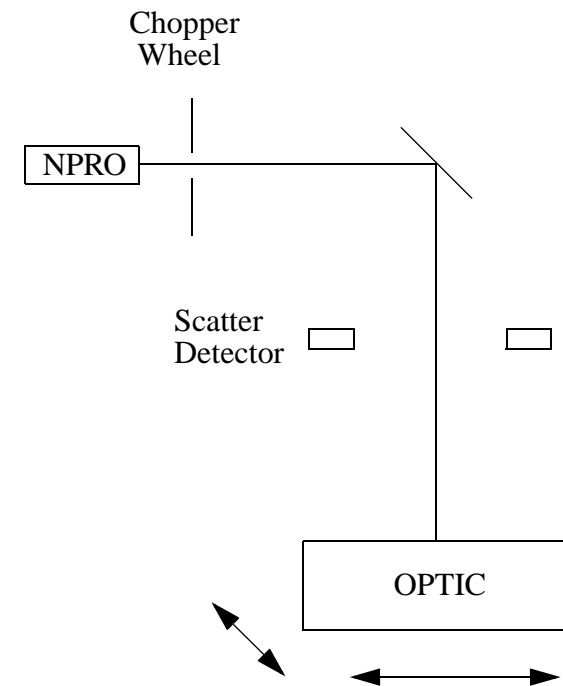
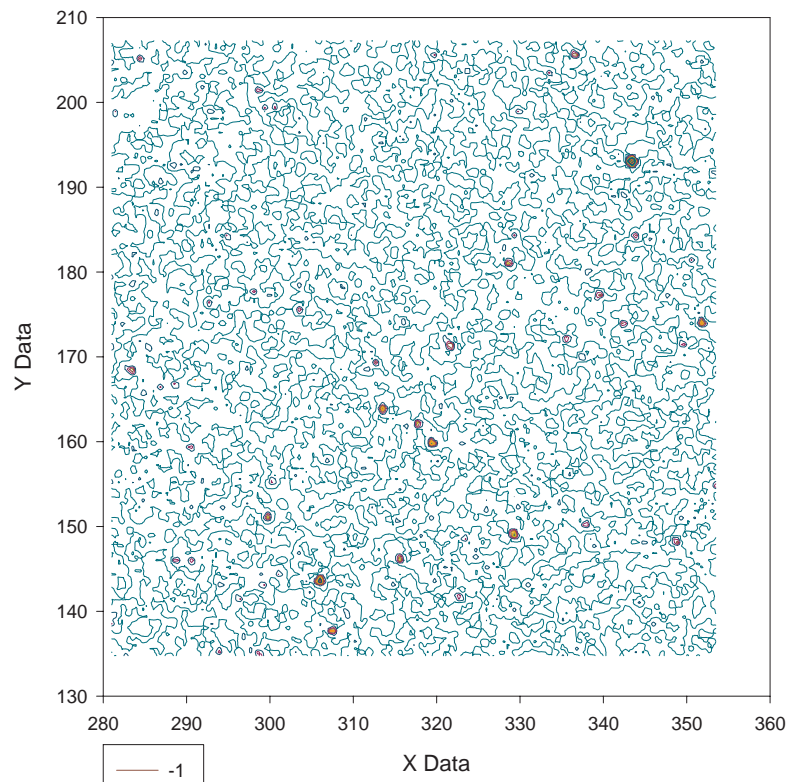
- Surface Defects

- ›› measured with Core Optics Loss Scanner

- ›› < 5 ppm total

ITM Scatter Measurement

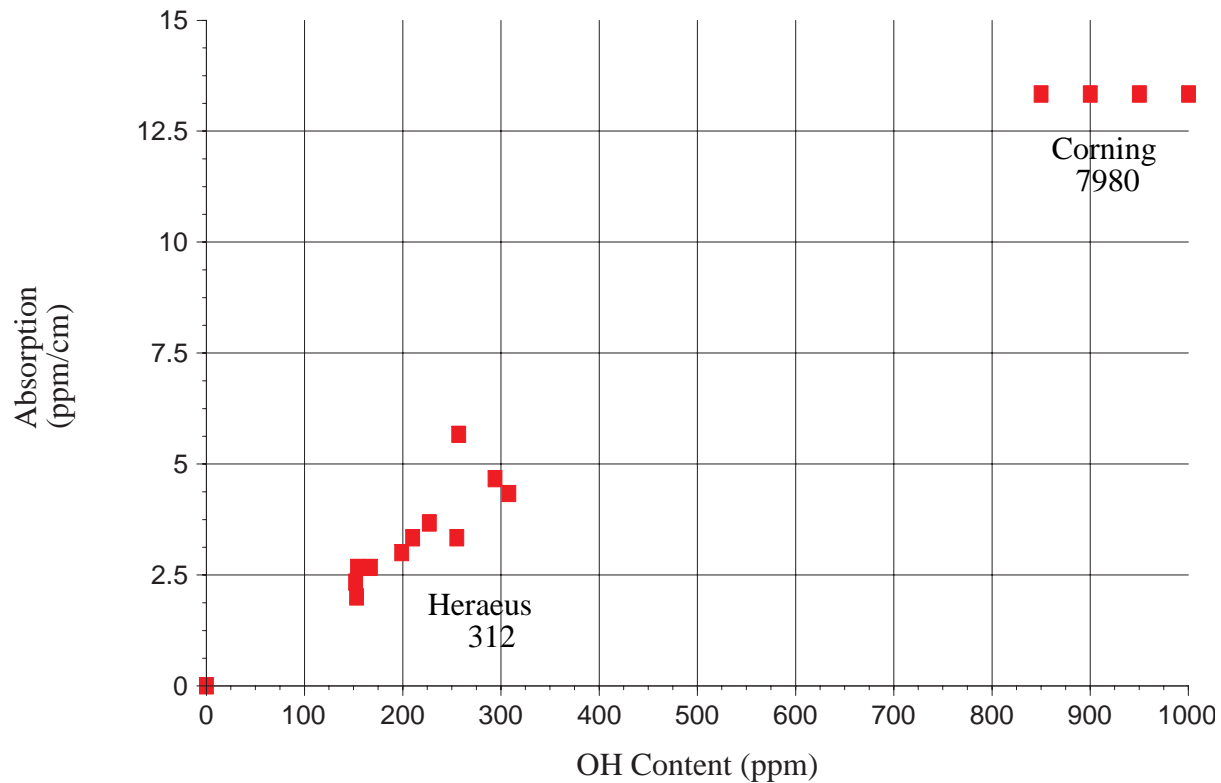
S. Bell, D. Li



- Loss from defects < 5 ppm

Absorption Loss : Substrate

G. Billingsley

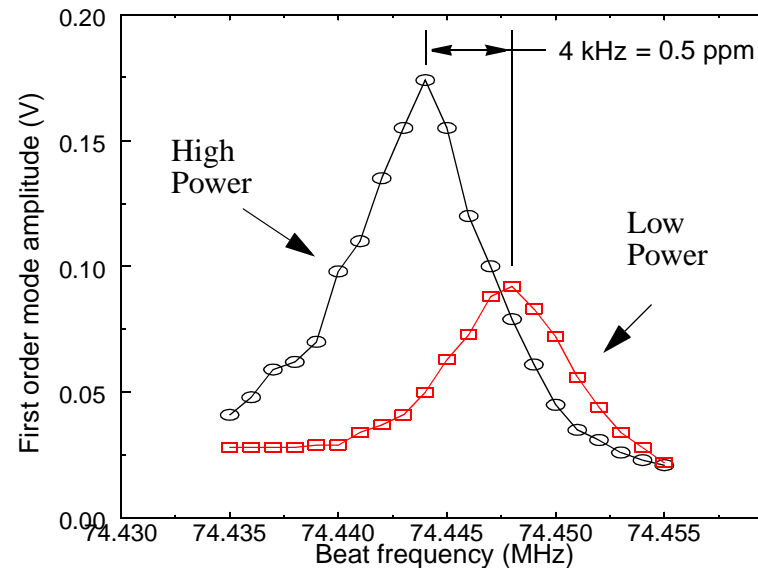


- Absorption measured by photothermal deflection

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 CO₂ Snow
 - ›› CO₂ 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!