

Sapphire Development Program Status

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LSC meeting
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Sapphire as Test Mass Material

- High mechanical Q, increased density for Sapphire relative to fused silica
- Range for NS-NS coalescence
 - ›› ~ 220 Mpc for sapphire
 - ›› ~ 180 Mpc for fused silica
 - ›› assumes 6 cm beam spot, 30 - 40 kg test masses
 - ›› uncertainties in materials parameters (thermal conductivity, expansion coefficient, etc.) at 10% level

Sapphire Test Program

- Evaluate small samples from sapphire vendors (200)
 - ›› Crystal Systems, Boston
 - ›› SIOM, Shanghai
- Feed back info to vendors to grow full size samples (2001)
- Sapphire parameters
 - ›› Mechanical Q
 - ›› Absorption
 - ›› Birefringence
 - ›› Polish

Mechanical Q

- Measured for a number of samples
 - >> 15 cm dia. x 6 cm
 - >> 8 cm dia. x 2 cm
 - >> 2 cm dia. x 10 cm
- Q consistently greater than 2×10^8
- *Need to measure effect of coating, attachments on Q*
- Anelastic loss measurements at Syracuse: off-resonance thermal noise
TNI

Absorption

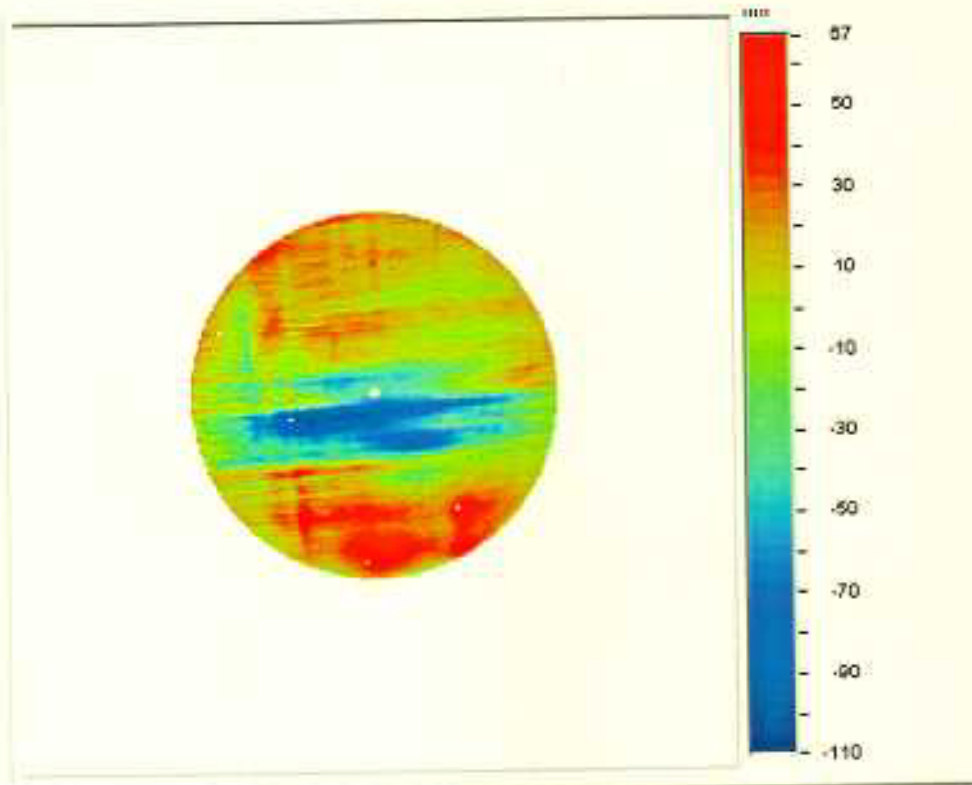
- Coating absorption < 1 ppm, c and m axis
- Substrate absorption
 - ›› 80 ppm/cm average, no correlation with starting material or location
 - ›› 20 ppm/cm sample identified (Australia)
 - may have to do with sample annealing
 - ›› next series of absorption measurements to study annealing
 - vary temperature, pressure, composition of anneal
- 80 ppm/cm requires factor of 4 in thermal compensation

Birefringence

- Concern for m-axis crystal
 - ›› full size crystals grown by CS in m-axis direction
 - ›› concern for both substrate and coating
- Preliminary coating measurement gives $\Delta\phi \sim 10$ mrad
 - ›› measured birefringent splitting of resonant mode of FP cavity
 - ›› acceptable level if optic aligned to 1 degree with polarization of light
$$(\theta_{align} \Delta\phi G_{arm})^2 < \frac{1}{G_{RC}}$$
 - ›› need to map birefringence over large area
- Substrate not expected to be problem but will study

Polish

- Half size test pieces to test sapphire polishing capabilities of vendors (CSIRO, GO)
 - ›› microroughness requirement 0.2 nm already demonstrated
 - ›› surface figure requirement 0.5 nm rms needs to be demonstrated
- Optical homogeneity ~ 150 nm P-V for 8 cm thick CS pieces
 - ›› surprisingly good!
 - ›› needs to be reduced by factor ~ 3 by compensating polish of 2nd side (hard)



Date: 08/04/2000

Time: 15:43:44

Wavelength: 690.700 nm

Pupil: 100.0 %

PV: 176.8397 nm

RMS: 30.1551 nm

Rad of curv: 0.00 km

X Center: 280.00

Y Center: 280.00

Radius: 144.00 plx

Terms: Tilt

Filters: None

Masks:

Ref Sub:

Averages:

Summary

- Mechanical Q OK
 - ›› need to measure effect of coating, attachments
 - Coating absorption OK
 - Birefringence probably OK
 - Polish probably OK
 - Absorption too high, but still working on it.
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- Does the modest (~20 %) benefit justify the effort to develop sapphire?