LIGO-G010084-00-R

Syracuse Coating Results

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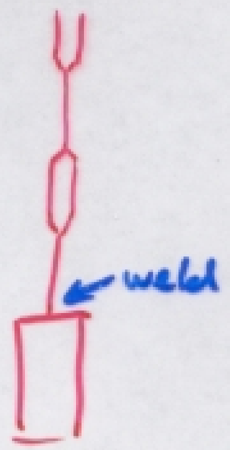
The measurements

• Thin Samples

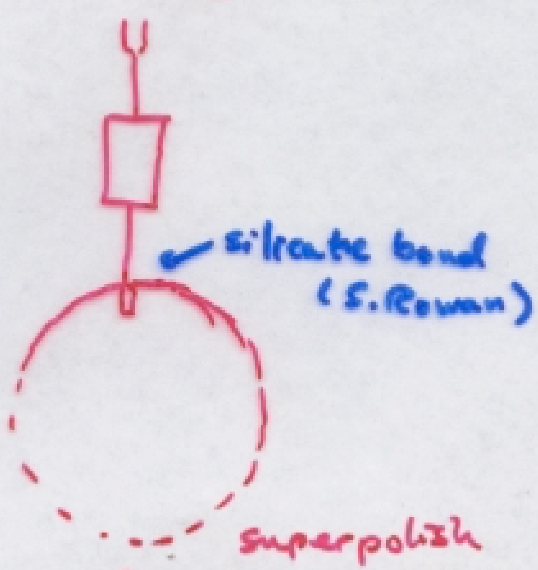
robust ✓
analytic ✓
flatness ?

2 slides



comm. polish
1mm thick
10 layer coating
2.4μm thick.

1 disk



superpolish
2cm thick
38 layer coating
24μm thick.

Measure Q before & after coating

$$\phi_{after} = \phi_{before} + \frac{E_{coat\parallel}}{E_{tot}} \phi_{coat\parallel} + \frac{E_{coat\perp}}{E_{tot}} \phi_{coat\perp}$$

$\frac{E_{coat\parallel}}{E_{tot}}$ → Calculate {Analytic/FEA

$\frac{E_{coat\perp}}{E_{tot}}$ → 0 for free BC's.

	uncoated Q	coated Q (f~kHz)
Slide 1	—	$(1.1 \pm 0.5, 1.6 \pm 0.1, 1.6 \pm 0.1) \times 10^5$
slide 2	—	$(1.3 \pm 0.1) \times 10^5$
Disk	3.5×10^6	1.3×10^6

uncoated control slide Q's $(4.0 \pm 0.2, 4.4 \pm 0.2) \times 10^6$

Thinner disks being coated
→ Measure Q's soon.

<u>If</u> innermost interface rubbing is negligible we can define $\phi_{coat\,\parallel}$ (and $\phi_{coat\,\perp}$)

Results:

$\phi_{coat\,\parallel}$

slide 1 $\Rightarrow$ $(6.1, 4.2, 4.3) \times 10^{-4}$ 〃

slide 2 $\Rightarrow$ 5.1 $\times 10^{-4}$ 〃

Disk $\Rightarrow$ 3.2 $\times 10^{-4}$ 〃 ($\lesssim$ 20% uncertain)

Can use $\phi_{coat\,\parallel}$ to estimate S_{th} due to coatings.

Taking $\frac{Y_{coat}}{Y_{subst}}$ into account get estimates for both Silica & Sapphire.

Single test-mass displacement internal mode thermal noise:

$$S_{th}(\omega) = \frac{2 k_B T (1-\sigma^2)}{\sqrt{\pi}\,\omega\, Y_{subst}\, W} \phi_{readout} \quad \left[\frac{m^2}{Hz}\right]$$

↑ W: Beam $\frac{1}{e}$ field width

$\phi_{readout}$ is the loss angle assoc. with the response to a cyclic Gaussian force.

$$\phi_{readout} \approx \phi_{bulk} + \frac{1}{\sqrt{\pi}} \frac{(1-\sigma_{subst})}{(1-2\sigma_{subst})} \frac{d}{W} \times \left(\frac{Y_{coat}}{Y_{subst}} \phi_{coat\parallel} + \frac{Y_{subst}}{Y_{coat}} \phi_{coat\perp} \right)$$

← W: Beam width

↑ $\phi_{coat\parallel}$: measure

↑ $\phi_{coat\perp}$: ?!

(ellipsometry?)

5.

Sapphire: $\frac{Y_{subst}}{Y_{coat}} \sim 36$ —emphasises→ $\phi_{coat\perp}$

Silica: $\frac{Y_{subst}}{Y_{coat}} \sim 0.7$ ~~small emphasis on → $\phi_{coat\parallel}$ and $\phi_{coat\perp}$~~

→ emphasises $\phi_{coat\parallel}$

To estimate $\phi_{readout}$

assume $\phi_{coat\parallel} = \phi_{coat\perp}$

(Not tested...)

Results for silica: (ETM, 6cm spot) $\phi_{bulk} = 3\times10^{-8}$

"$Q_{readout}$" $\equiv 1/\phi_{readout}$

Slide 1 ⇒ $(4.5, 6.6, 6.4)\times10^{6}$ "

slide 2 ⇒ 5.4×10^{6} "

Disk ⇒ 8.7×10^{6} "

?? Likely worse for sapphire...??

Possible Solutions

- Reduce $\phi_{coat\parallel}$ & $\phi_{coat\perp}$
- Thinner coatings / fewer layers
- $\sqrt{S_{th}} \sim \frac{1}{w}$ ⇒ increase spot size
- cool the test-mass

Summary:

"Smoke on the water..."