Status reports for the CO Working Groups, Thursday, May 9, 2002

Helena: Coating Status

Received 2 polished blanks manufactured from Suprasil 311 SV. The substrates are being measured for "Q" at Stanford.
Further processing TBD

MLD
One Ta_2O_5 / SiO_2 coating run failed at MLD as consequence of a mechanical failure in the coater. All the parts were lost.
The run is being repeated at this time.
Because MLD can not anneal coatings higher than 500º C we may have one substrate of each type annealed at MLD at 500º C and the other 2 at SMA/Lyon at 600º C.
This may help determine if there is a contamination issue within their coating process or with their annealing procedure.

SMA/Lyon
In early June SMA will deliver "Q" substrates coated with 30 layers - 1/8 wave of Ta_2O_5 and 3/8 waves of SiO_2.
To complete the last tasks in the Memorandum of Understanding with EGO/SMA we may get some coatings manufactured where the Ta_2O_5 is doped to modify its properties. Ta_2O_5 is a well understood material, its optical properties are close to Advanced LIGO requirements so it will be helpful to exhaust all possibilities of improvement before a new material is fully researched. Also, the test of different materials on the large coater at SMA is difficult because the cost of the targets is very high. As an example, the price for a high purity and flat HfO_2 target is ~$30,000.00.

Garilynn: Polishing Status

Advanced LIGO Test Masses-
A draft specification and drawing for the LASTI Test Mass was completed, this is also a first article ITM. The drafts have been sent to crystal systems for quote.

http://ligo.caltech.edu/~gari/LIGOII/E020389-01_LASTI-TM.pdf
http://ligo.caltech.edu/~gari/LIGOII/D020150-02-LASTI-TM.pdf

Homogeneity Compensation - Goodrich has delivered the 25 cm sapphire blank with compensating polish.
I've measured the homogeneity of the piece. The good news is that they have compensated the inhomogeneity of the piece. See the image at http://www.ligo.caltech.edu/~coreopt/GoodrichComp.JPG This represents the central 150 mm diameter of the piece. The measurement is through side 2 (see below) reflecting

off side 1 and back through the bulk. I have not subtracted side 1, yet, this is the situation where the homogeneity appears best.

See the Goodrich data at: http://docuserv.ligo.caltech.edu/docs/internal/C/C020137-02.pdf (yes the first page is blank..oops.) I believe they have subtracted surface 1 in this view. The blob at 8 o'clock may correspond to what I measure at 12 or 6 o'clock.

The bad news is that the piece appears badly scratched, either that or it has something on the surface that doesn't clean with acetone and methanol. The surface specifications were waived in this instance because the piece has several bubbles breaking through the surface, Goodrich can't possibly control the bubbles. However it is interesting to note that most of the "inhomogeneity" now comes from the scratches and spiral machining marks.

The other bad news is that they appear to have confused which side they should be working on. What was a nice 4nm surface on side 1(former) is now the compensatED surface (the new side2) This is proven by the characteristic defects at the bottom of both upper images at http://www.ligo.caltech.edu/~coreopt/SurfacesPostComp.JPG
This image shows the clockwise change of the surfaces
Surface 1 before Goodrich (upper left)
Surface 1 after Goodrich (now surface 2 the "compensated" surface)(upper right)
Surface 2 before Goodrich (lower right)
Surface 2 after Goodrich (now surface1)(lower left)

It's interesting that (speaking currently now) the compensating polish compensates for an error polished into Side one (did they try compensation on this surface at one time?), yet the specification calls for the side one data to be subtracted from the inhomogeneity.

I have been in touch with Goodrich regarding these results. They believe that they can take out the spiral features on side 2. They have no idea what the scratches are, they don't think it comes from dirt because the piece was cleaned before it left Goodrich.

Mechanical Loss:

<u>Sheila/Gregg</u>

On the coating thermal noise project, we measured Q's on sample 3a which was coated by MLD with a tantala/alumina coating. Based on previous measurements of a tantala/alumina coating applied by Wave Precision (General Optics) made by the Glasgow/Stanford collaboration, we expected a Q a little above 1 million. We found, for both butterfly modes Q's of 88,0000 and for the drumhead mode a Q of 69,000. These give values of phi_coating of 9 10^-4 and 1 10^-3, respectively. This is compared to the result obtained by Glasgow/Stanford for the Wave Precision coating of 6.4 10^-5. We are now discussing ways to determine what is different about the MLD coating compared to the Wave Precision one to better understand what is causing the internal friction in the coatings.

This sample has also given us evidence of Q degradation due to charging of the sample. The first measurement on the butterfly mode of this sample gave a Q of 21,700. Upon opening the bell jar, we measured the electric field using an Electrostatic Fieldmeter. The field was as high as 340 V/inch. Using a nitrogen gas deionizer, we removed the charge so that the field read 10 V/inch (about the sensitivity of the device). Upon remeasuring the Q after deionizing, the Q was found to be the 88,000 described above. We are in the process of trying to understand, explain, and reproduce this measurement.

We also examined the effect of baking on the coating loss. We took sample 3, which is coated with 30 even layers of silica and tantala by SMA/Virgo, and baked it for 24 hours in air at 115 C. We then rehung it and are in the process of remeasuring the Q. So far we have only found the X butterfly mode, but it has a Q of 536,000 compared to 532,000 before baking. So it doesn't appear that baking at this low a temperature has any effect on the Q.

Plans for Coatings project

There are samples coated at MLD with tantala/silica to be annealed. The samples will be annealed and analyzed for optical loss first and we wil then use the results to make a decision about how to anneal the mechanical loss samples. The optical loss samples will be annealed two at a time at three different temperatures; 400 C, 450 C, and 500 C. Whichever temperature gives the best optical loss will be used on the mechanical samples, and we preserve the option of sending some samples to SMA/Virgo for annealing if higher temperatures prove to be best.

The next coating run at MLD will be niobia/silica. This coating has been shown to have low optical loss, but we haven't measured a Q on a coating containing niobia. The next coating run at SMA/Virgo will be 3/8 lambda silica-1/8 lambda tantala. Using the results of the previous round of Q measurements we can predict the Q from this coating, so this will be a test of our understanding of coating loss at this stage. There is a proposal to do the subsequent coating run at SMA/Virgo with doped tantala in a tantala/silica coating. We will wait until we have results from the above coatings before making a decision on this.

Update on coating phi's

We now know that the tantala/alumina coating from MLD had 47 layers, starting and ending with tantala. The tantala layers were 130.12 nm thick and the alumina were 162.7 nm, for a total coating thickness of 6.9 microns. Using this thickness and the measured Q's on the thin samples at MIT gives coating phi's of

phi_coat_bf = 1.1 +/- 0.1 10^-3
phi_coat_dh = 1.3 +/- 0.1 10^-3

Slightly more lossy than calculated before. A preliminary result from the same coating measured at Glasgow gives

phi_coat = 3.6 +/- 0.4 10^-4

This subtracts off the loss from a mass annealed at SMA/Virgo. An MLD annealed sample just arrived in Glasgow, measurements on it are beginning. Q measurements on thin samples like the MIT sample are also beginning at Syracuse.

Ju Li/David Blair: High Optical Power Test Facility Project Summary (Perth)

Here are the activities down here for last month:
· Preliminary installation of a 3 stages vibration isolator with Euler springs in Gingin.
· Completed the manufacture of a electrical static actuator for test mass and testing gear.
· Finite element modeling of thermal lenssing in sapphire is under way.

Also, in the 5:00 pm telecon, there will be more discussions on the high power test facility and sapphire substrates:
The LIGO Laboratory have proposed supplying LIGO1 type small optics suspensions with sapphire test masses for use in the Gingin tests. In addition, the candidate suspension that we are suggesting for Gingin can be found at
http://www.ligo.caltech.edu/docs/D/D960001-C.pdf

Mike Z. summarized the pros and cons of the selection:

- The thermal gradients that matter are within a beam radius or so, and the radiative boundary condition at the periphery scales simply (basically, a DC thermal offset temperature depending on how much material is between the source and the radiating surface). Ryan's simulations of the scanned-beam heater bear this conjecture out.

- The smaller pieces have significantly better optical uniformity. This improvement is evidently more than one would expect from just the fact that the smaller blanks are thinner; Gari feels it could be because there is more freedom to select good zones from the boule when the finish size is smaller. The leadtime for small pieces is also much shorter so starting over would not drive the schedule much.

Although folks are apparently still thinking deeply about whether the wiggly 15 cm m-axis pieces we have will even "work," given their measured inhomogeneity, it's likely that whatever the inhomogeneity problem it'll be much less an issue with smaller mirrors.

- The other true "grail" of the Gingin experiment besides thermal loading, if we have our druthers, is to investigate the cavity length and alignment dynamics under photon pressure. A lighter mirror will enhance such effects and make them easier to study.