LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY

LIGO Laboratory / LIGO Scientific Collaboration

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Further investigation of Hanford ITM absorption

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1 Recommendations

The core optics group recommends further measurements to confirm and monitor performance of the Hanford core optics. In summary the recommendations are:

1. Establish the ability to monitor the vacuum quality and contaminants of the 4K ITM chambers with high accuracy via calibrated RGA or quartz micro-balance monitor.
2. Install an air lock on one 4K ITM chamber to provide a mechanism for installing and removing sample optics for the purpose of contamination analysis.
3. Repeat the cavity measurements done before the replacement of ITM-x to confirm that all absorption was caused by the ITMs.
4. Repeat scatter measurements (per Kells) now and on an ongoing basis, 1/month recommended for the near term.

These recommendations are based on post-replacement findings, both in H4 interferometer performance and in post-mortem examination of 4ITM07, recently removed from the Hanford ITM-x position.

2 Findings

Hanford 4K ITMS were found to be highly absorbing as described in T050074-00.

2.1 Current H1 performance

The current performance of H4 indicates little absorption from either ITM. This implies that the drag wipe of ITM-Y removed the ~10ppm absorption indicated by pre-replacement cavity and TCS measurements. From this we can conclude that the absorber was present only on the surface(s) and was soluble in methanol. The HR side of ITM-Y was only wiped a couple of times according to G. Traylor (Appendix A.) The AR side took quite a long time to clean.

2.2 Measurement of 4TIM07

Initial inspection of 4ITM07 upon arrival at Caltech is described in T050117-00.

The absolute calibration of the scatter and absorption measurement system at Caltech is not yet established. We do have measurements of bulk and coating absorption from optics that have also been measured at Stanford. Most of the measurements are therefore relative.

The bulk absorption has been measured at 4ppm average, this is comparable to other ITMs which also measure at the few ppm level.

As of this writing we can conclude that there are point absorbers present on the HR surface, the absolute level of their absorption is not yet established. The background absorption level averages about 1.5 ppm with the current calibration. It should be noted that we suspect some of the particulate contamination on the HR surface may come from the transit case or shipping container. See T050175 for preliminary information. While there is some correlation between points that scatter and points that absorb, we can not claim to know if the transit case contamination adds to the overall absorption.

2.3 Baffle Analysis

XPS (X-ray Photoelectron Spectroscopy) analysis was done on the glass baffle side that showed a faint haze. This is the baffle's surface facing the mode cleaner. A three times higher concentration of Na (sodium) is observed on this side. It appears that only one side of the baffle is contaminated with sodium. T050145-00.

3 Recommendations

3.1.1 Monitor Vacuum

Establish the ability to monitor the vacuum quality and contaminants of the 4K ITM chambers with high accuracy via calibrated RGA or quartz micro-balance monitor. It is clear that the H1 ITMs were contaminated, what is not clear is the type and origin of contamination. Precision monitoring of the vacuum will help quantify or eliminate the vacuum system as a source of contamination.

3.1.2 Air Lock

Install an air lock on one 4K ITM chamber to provide a mechanism for installing and removing sample optics for the purpose of contamination analysis. Removal of a core optic is (hopefully) too rare an occurrence to rely on for study of optical loss mechanisms within the interferometers.

3.1.3 Confirm cavity performance

Repeat the measurements described in T050074-00 which were done before the replacement of ITM-X to confirm that all absorption was caused by the ITMs. For completeness in investigating the cause of contamination, we should eliminate the possibility of absorption by the ETMs. This also provides for a baseline against which future cavity measurements can be compared.

3.1.4 Monitor scatter

Repeat scatter measurements (per Kells) now and on an ongoing basis, a frequency of once per month is recommended for the near term. It is important to establish a baseline immediately, so that future measurements need only be simple, relative checks.

4 Conclusions

We have either a contamination problem or a measurement/characterization problem. The absorption measurements at Caltech account for roughly 2 to 10 times less absorption than the observatory cavity measurements indicate. This spread is dependent upon uncertainty in the calibration. We should approach the problem from both angles until we understand the causes. We will continue to pursue calibration of the absorption test stand and rigorously account for point absorbers. We should also rigorously monitor the 4K vacuum and ITMs for signs of additional contamination.

Appendix A – G. Traylor
This is a brief statement of my findings before cleaning ITMY at LHO.
Upon first inspection of the ITMY large particulates were seen on the AR and HR side of the optic.
At closer inspection it was noted that there was a film of some sort dominantly on the AR coated side of the mirror that appeared to be blotchy patches covering about ~80% of the AR side.
The HR coated side of the optic was not nearly as dirty as the AR side. It was mostly particulates that, at best guess, 1 per 4 square cm varying in size.
The outer band of the optic was covered in what looked like large smears of some sort.
The PO mirrors appeared to have a similar film as the AR side of the ITMY and very few particulates.
The elliptical baffle had particulates on it but I never really looked close to see if there was a notable film.
At a very distant inspection of the BS (~ 6 feet) there were also particulates on both surfaces of the mirror.
The AR surface was drag wiped clean using Lensex 90 and high purity methanol. The film was very difficult to remove completely from the mirror because of the OSEMs and magnets on the AR surface but we did manage to move all of the film from the center of the optic to the edges of the mirror past what I call OSEM square.
We then attempted to drag wipe the HR coated side but only made two passes over the center of the mirror because there was no noticeable film on this side of the mirror and there was no noticeable clean trail after the lensex passed across the mirror.
The entire optic was blown with CO2 to remove particles from the surface.
I placed 3 witness plates at various positions throughout BSC1. The first was placed on a shelf just above the PO mirror well out of the beam path but in close proximity to the ITM. The second was placed in a 10" flange at the opposite corner of the flange that houses the ITM camera. The third was placed at the base of the BSC door on the vertex side if BSC1.
Gary Traylor