LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY

LIGO Laboratory / LIGO Scientific Collaboration

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Characteristics of ETM05 with LMA coating

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1 Introduction

GariLynn measured the phasemap of ETM05 with LMA coating on it, E1200093-v2. The loss due to this phasemap is analyzed and the systematic uncertainty is estimated using old measurement, E1200093-v1.

2 LMA coating for ITM use

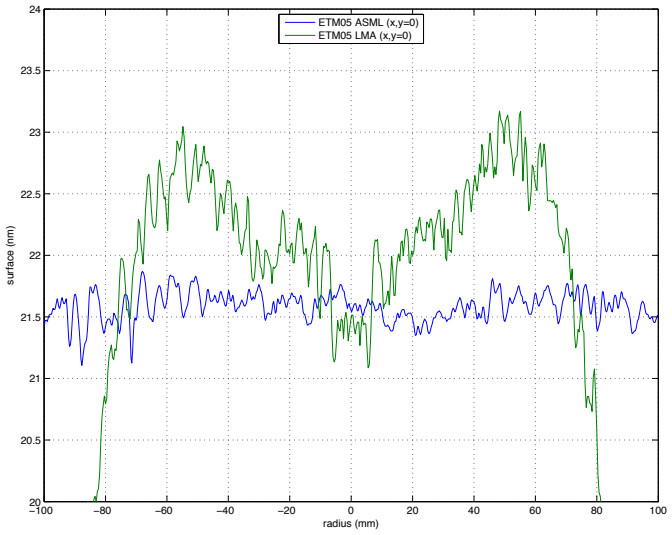

Figure 1 ETM05 : polished surface vs coated surface

Figure 1 compared the polished surface of ETM05 using the map given by ASML, referred to as ETM05-ASML, and the coated surface using the map in E1200093-v2, referred to as ETM05-LAM-v2 here after.

Figure 2 below compares three PSDs, ETM05-ASML, ETM04-ASML and ETM05-LMA-v2. As is seen from Fig.1, the short wavelength variation of ETM05-LMA-v2 is larger than that of ETM04-ASML, and this is seen in Fig.2 as well in the high frequency region. I cannot believe that the coating can introduce this short wavelength noise, and this will come from systematic errors introduced in the measurements. Also seen from Fig.2 is that LAM-v2 has enhancement in the low frequency region (> 2cm). This may come from coating process or insufficient subtraction of the substrate structure, either intrinsic or one introduced in the annealing.

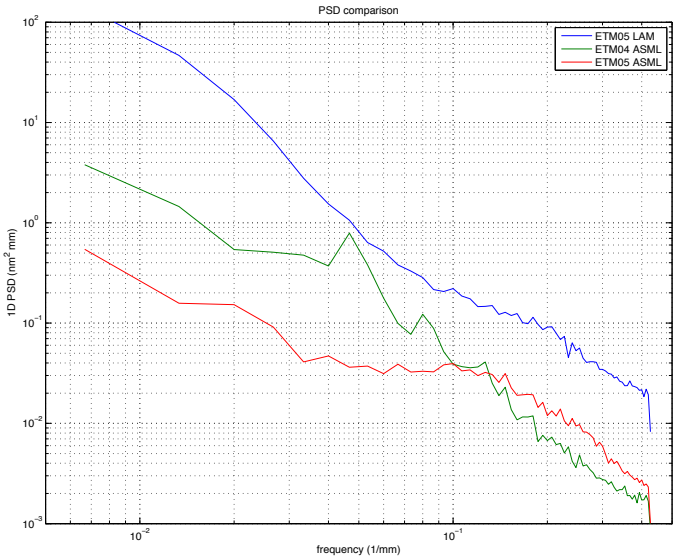

Figure 2 Comparison of PSDs

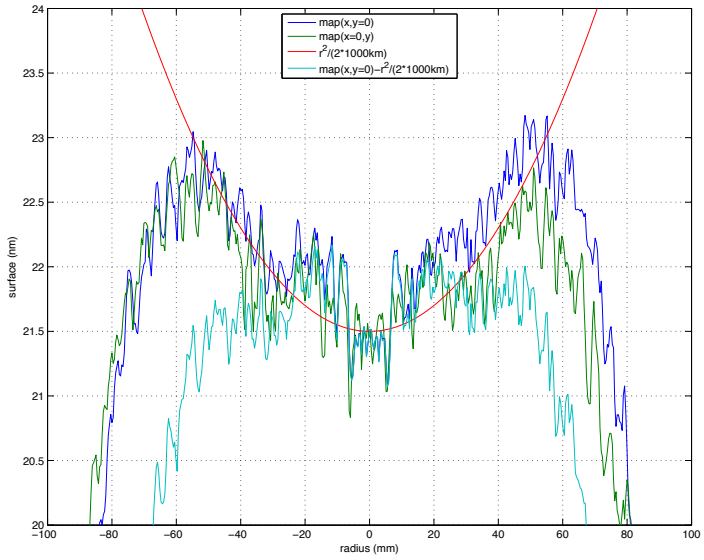

Figure 3 Comparison of curvatures, 150mm flat or smaller area flat

In Figure 3, blue and green lines show the cross section of LMA-v2, along x axis and along y axis. When the curvature is calculated in the central 150mm region, the power term becomes small, i.e., average curvature is infinite. But as the red line shows, there is finite curvature in the smaller central region. The light blue line is blue line – red line, i.e., power term is modified by a little bit, only 1000km. This changes the curvature value by 2000m / 1000000m ~ 0.2%. This will be smaller than the accuracy of measurement. By using this power term, the map becomes flatter in the central region, but the fall off at the outer region becomes more prominent.

In order to see the implication of this observation, the diffractive loss and the higher order mode contents are calculated for various cases.

	Case	Diffractive loss	Higher order mode fraction
1	ETM04 ASML	1.9ppm	Negligible
2	ETM05 ASML	4.4ppm	Negligible
3	ETM05 LMA v2	4.8ppm	9ppm
4	ETM04 LMA v2 + 1000km ROC correction	4.8ppm	40ppm
5	ETM05 LMA v1 (E1200093-v1) + 200km	16ppm	~70ppm
6	ETM05 LMA v2 + 1000km ROC + 6.4nm Zernike(2,2) – 2.1nm Zernike(2,-2)	16ppm	~70ppm
7	[ETM05 LMA v2] x 2 on ETM	26ppm	256ppm

Table 1 Loss and higher order mode

As you see by comparing case 4) and 5), this curvature difference make the higher order mode content different. (In terms of height, they differ by 1nm, and surface roughness requirement is a few angstrom, and this small difference is not surprising.

Two estimate the Zernike term ambiguity, two methods were tried. One is to use the map in E1200093-v1 as is (200km is added to make the central region flat, see Fig.4)

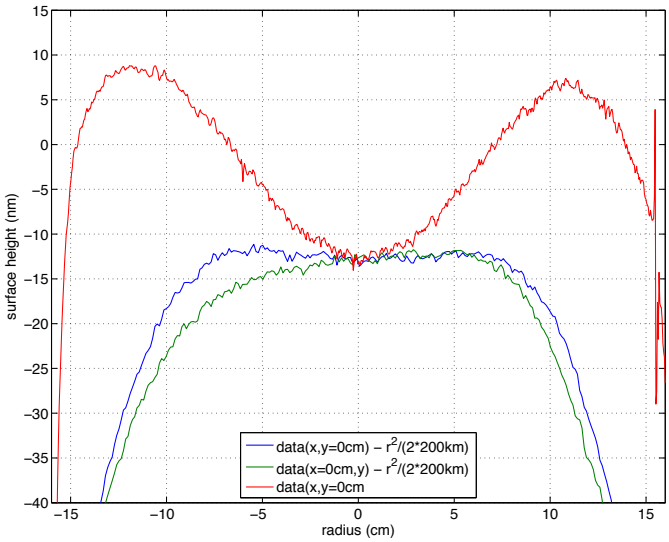

Figure 4 E1200093-v1 data

Second is to add the subtracted Zernike term back to E1200093-v2. Case 5 and 6 in Table 1 shows the result. As you see, the diffractive loss is acceptable.

So the loss and higher order mode fraction seem to be acceptable to be used for ITM.

3 LMA coating for ETM use

The result of the loss when the phasemap LAM-v2 is multiplied by 2 is placed on ETM is shown in the table 1, item 7. The diffractive loss is 27ppm, around 4 times of 4.8ppm.

The higher order mode is much larger than 4 times of the case when LAM-v2 is used for ITM. The reason will be because the beam size on ITM is 5.3cm, while that on ETM is 6.2cm. The shoulder structure occurs in a region with more field power for the case the map is placed on ETM.

4 Conclusion

Based on these variation case study, my personal opinion is to go for the Heraeus mirror coating to learn more solid.