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LIGO Optical Contamination Tests of the PEEK Unwound Spools

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Abstract

This report gives the result of the high power exposure test of the PEEK unwound spools.

1 Introduction

To achieve its goal, LIGO has set a limit on the rate of increase in loss for its optics of no more than 10 ppm/year/optic scatter and 0.5 ppm/year/optic absorption[1]. Representative samples of each material and component included in LIGO's vacuum system must be screened experimentally, including two aspects: Initial determination and QA screening[1]. As a part of the initial determination, a high power exposure test based on a high-finesse Fabry-Perot cavity and the rf reflection-locking technique has been developed to evaluate the candidate material for optical contamination potential under high laser power in the presence of high reflectance mirrors [2,3,4,5]. This report gives the test result of the PEEK unwound spools .

2 Sample Description and Preparation

To be filled.

3 Results and Discussion

3.1 Measurement results

Fig.1 shows the test results of the PEEK unwound spools. Table 1 is a comparison of the test results of the sample with that of the empty chamber. Although we do not expect each test to have the same background, a conservative estimation could be obtained by subtracting the reference running result of the corresponding empty cavity, i.e. 0±0.8 ppm/year/optic absorption and 3±3 ppm/year/optic total loss (scatter). A conservation factor of 2 has been included in above estimation since the test cavity has two mirrors.

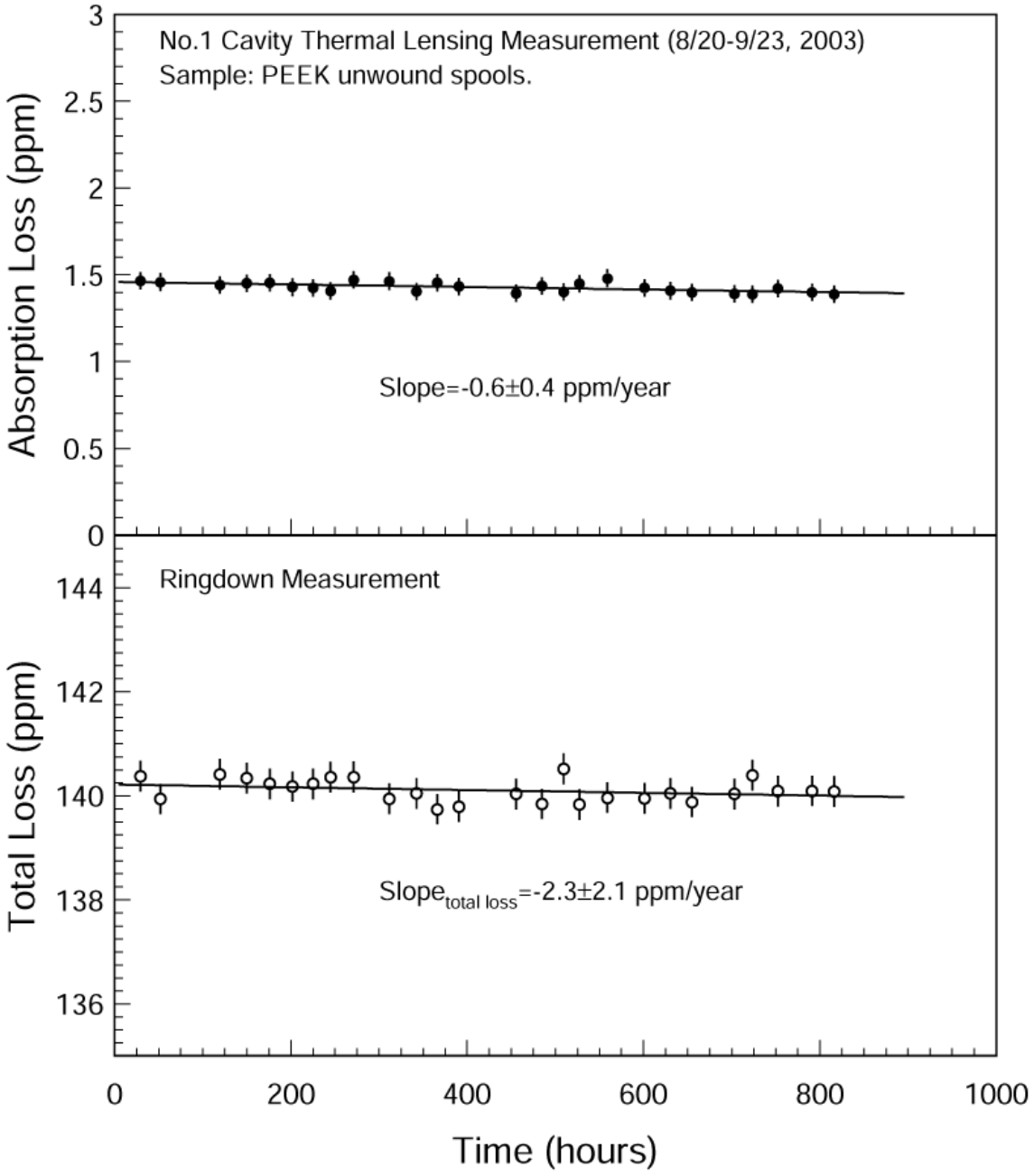

Fig.3 The mirror surface absorption and the total loss versus time of the cavity 1 without sample.

Table 1. Comparison of the result of the PEEK unwound spools and that of the empty chamber.

Sample	Cavity No.	Absorption loss rate (ppm/year)	Total loss rate (ppm/year)
No sample	1	-0.2 ± 0.7	-5 ± 2
4 PEEK unwound spools	1	-0.6 ± 0.4	-2 ± 2

3.2 Scaling of the results to LIGO

Extrapolation of the optical losses in LIGO from the high power exposure tests have been discussed in detail in refs.[1, 2, 6]. In current test, the light intensity on the two cavity mirrors are ~800 KW/cm^2 and ~500 KW/cm^2, respectively, they are pretty close to the highest level (~725 KW/cm^2 , LIGO-T020027) planned in the Advanced LIGO, so the following formula is used to scale the test result to LIGO-I and Advanced LIGO :

$$\dot{L}_{LIGO} = \dot{L}_{TEST} \frac{A_{LIGO}}{A_{TEST}} \frac{S_{TEST}}{S_{LIGO}} \quad ,$$

where:

$\dot{L}_{LIGO}$ is the extrapolation of the increase rate of optical loss from the lab high exposure test to LIGO,

$\dot{L}_{TEST}$ is the test result of optical loss increase rate,

A_{TEST} and A_{LIGO} are the material surface areas in the test chamber and LIGO envelope respectively, and

S_{TEST} and S_{LIGO} the pumping speeds of the test chamber and LIGO envelope respectively.

As discussed in refs.[1, 2], in the most conservative case, i.e., the contaminants do not adhere to the chamber walls and the only pumping action is provided by the pumping system itself, the S_{TEST}/S_{LIGO} is about 1/50. For the four spools in LIGO, i.e. the A_{LIGO}/A_{TEST} is 1, the estimated absorption and total loss rates are 0.00±0.02 ppm/year/optic and 0.02±0.02 ppm/year/optic respectively, as summarized in table 2, they are within the LIGO requirements. Therefore, an extremely conservative estimation of acceptable amount of these units is ~100.

Table 2. Derived loss increase rate of the high power exposure tests and its extrapolation to LIGO.

4 PEEK unwound spools	Absorption loss rate (ppm/year/optic)	Total loss rate (ppm/year/optic)
In the high power exposure test	0.0 ± 0.8	3± 3
In LIGO	0.00± 0.02	0.06 ± 0.06

Acknowledgments

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