LSC Six-Month Progress Report

Organization Stanford Advanced Gravitational Wave Interferometry Group
Report Date February 15, 2003

Attachment B - Isolation, Suspensions and Thermal Noise Development Group
For the period August 2002 to February 2003

Materials and Thermal Noise
(S. Rowan, E. Gustafson, R. Route, M. Fejer)

1. Investigation of losses of dielectric mirror coatings. In collaboration with the Universities of Glasgow, Syracuse and MIT, and Caltech we have continued our studies of the Q factor of fused silica samples, 3-inch diameter by 1-inch thick, supplied by LIGO to study, and reduce, the mechanical losses of coatings.

a.) We have extended our investigation of the mechanical loss factors of SiO_2/Ta_2O_5 coatings, and have

i.) completed a draft publication summarizing the outcome of these experiments, (submitted to Classical and Quantum Gravity) S. Penn, P. Sneddon, H. Armandula, J.C. Betzwieser, G. Cagnoli, J. Camp, D.R.M. Crooks, M.M. Fejer, A.M. Gretarsson, G.M. Harry, J. Hough, S.E. Kittelberger, M.J. Mortonson, R. Route, S. Rowan, C.C. Vassiliou, "Mechanical Loss in Tantala/Silica Dielectric Mirror Coatings,"

ii.) analyzed the frequency dependence of coatings containing different proportions of SiO_2/Ta_2O_5 . Our analysis suggests that there is a shallow frequency dependence to the coating mechanical loss, with the loss improving towards lower frequency. Modeling this loss as 'intrinsic' dissipation associated with the individual coating materials suggest the frequency dependence is associated with the SiO_2 present in the coatings.

b.) Measurements of the loss factors of silica samples coated with Al_2O_3/Ta_2O_5 and SiO_2/Nb_2O_5 coatings, respectively, have been carried out and we are in the process of measuring samples coated with SiO_2/Al_2O_3.

c.) A figure of merit for the expected thermal noise arising from the intrinsic dissipation of coatings of different materials has been calculated, and the importance of the relative material properties, in particular the Young's modulus, of the substrates and coatings has been identified. This, along with our current measurements, suggests that the most appropriate coatings are, for a fused silica substrate SiO_2/Ta_2O_5, and for a sapphire substrate Al_2O_3/Ta_2O_5.

2. At Stanford, Sheila Rowan, Helena Armandula and Jim Hough carried out the bonding of fused silica attachments to the Suprasil SV beamsplitter for GEO 600. Measurements of the residual reflectivity of the anti-reflection coating of this piece

were also carried out to verify that the coating was now in spec (after 'resurfacing' by REO). GEO 600 now has a full set of silica suspensions installed.

3. Analysis of the loss factors of hydroxy-catalysis bonding material used to bond silica and sapphire substrates has been completed, and a draft publication produced, (to be submitted to Classical and Quantum Gravity: P.H. Sneddon, S. Bull, G. Cagnoli, D.R.M. Crooks, E.J. Elliffe, J.E. Faller, M.M. Fejer, J. Hough and S. Rowan, "The intrinsic mechanical loss factor of hydroxy-catalysis bonds for use in the mirror suspensions of gravitational wave detectors,"

Active Alignment, Isolation and Control (D. DeBra, N. Robertson, B. Lantz, Grad Students: W-s Hua, C. Hardham, A. Ganguli, and J. Faludi)

g) We have collected paper-quality data from the Rapid Prototype, and have begun writing up the performance of that instrument. The displacement sensors have been removed and put onto the Technology Demonstrator.

h) We have measured the tilt-horizontal coupling of the Technology Demonstrator, and we have found it to be quite good. The measure of the quality of this coupling is the frequency and the linearity of the tilt-horizontal zero. The zero has a frequency of 20 mHz, (down from 150 mHz to 250 mHz of the Rapid Prototype). This is a substantial improvement, and qualifies our design method and flexure arrangement for the Advanced LIGO isolation systems. The high frequency modes of the outer stage have been measured, and are (slightly) above 200 Hz. The design goal was to be about 150 Hz, indicating success.

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