# LSC Six-Month Progress Report

**Organization** Stanford Advanced Gravitational Wave Interferometry Group
**Report Date** August 15, 2002

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

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

(a) Investigations into the level of excess loss introduced by dielectric mirror coatings applied to fused silica and sapphire samples;
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.

We have:

(1) Studied samples with identical coatings to those already measured to check reproducibility of measurements;
In collaboration with the University of Glasgow we have carried out analyses of duplicate samples of each kind of coating studied, and find that the values found for the mechanical losses of the coatings are consistent with first set of samples.

(2) Studied samples with coatings of the same design as those already studied, but coated by different vendors to check for vendor specific variability;
The coating loss was evaluated from measurements of fused silica substrates coated with silica/tantala dielectric coatings by MLD, of a design nominally identical to a coating produced by SMA Lyons. (30 alternating layers of quarter lambda thickness). The coating losses were found to be essentially the same, showing no significant signs of dependence on the vendor.

(3) Studied the loss factor of a silica/tantala coated sample with the proportions of silica and tantala reversed from previous measurements. This verified our predictions that the loss was predominantly associated with the tantala component; and

(4) Studied samples with coatings of different materials.
We have evaluated the loss factor of coatings fabricated by MLD using alternating layers of $Al_2O_3$ and $Ta_2O_5$. The coating loss was found to be 3.6 x 10-4, slightly higher than that measured for silica/tantala coatings. This is not consistent with previous measurements of this type of coating from a different vendor, WavePrecision Inc, which had a lower coating loss, ~ 7 x 10-5.

A publication on this work is in preparation and research in this area is continuing.

(b) Analysis of measurements of the loss factor of a coated sapphire sample to include the effects of the anisotropy of the sapphire material parameters (in collaboration with Glasgow);
The anisotropy of sapphire material properties is of a class that means a full anisotropic treatment is necessary for correct mode identification. The "I-DEAS" FE package was used to produce a fully anisotropic model and the results used to obtain a value for the loss factor of the coating. This was found to be (1.1 +/- 0.1) x $10^{-3}$. This coating was a silica/tantala coating applied by REO.

(c) Silicate bonding studies / Studies of excess loss in silica-sapphire silicate bonds / Studies of the effects of inhomogeneous mechanical loss on thermal noise (in collaboration with the University of Glasgow); and
We have been working to analyze the results from a series of Q measurements of samples of both silica and sapphire each of which had a fused silica attachment bonded to it by hydroxy-catalysis bonding. Measurements of bond thickness and Young's modulus will allow a value to be estimated for the loss factor of silicate bonding material.

The effects of inhomogeneous mechanical loss on test-mass thermal noise as sensed by a laser interferometer have been recognized and partially addressed in various publications, (Levin, Liu and Thorne, Nakagawa, Yamamoto et al). However currently there is no analytical method in the literature which can be used to calculate the expected thermal noise for a finite sized test mass with a particular spatially dependent loss. We have partially completed an analysis that should allow this, (Fejer et al in prep.) and work on this is ongoing.

(d) Participation in detector characterization
S. Rowan spent 28th June 02 to 6th July 02 working at the GEO600 detector site in Hanover.

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

e) The two-stage prototype has been used to demonstrate excellent performance in the microseismic band. In this band we have achieved or exceeded the requirements for Advanced LIGO, namely isolation in all three translational degrees of freedom of at least a factor of 10, and resulting motions of less than 2e-7 m/rtHz from 0.1 to 0.2 Hz.

f) We are continuing to receive and install instrumentation for the Technology Demonstrator.