



LIGO Laboratory / LIGO Scientific Collaboration

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ADVANCED LIGO

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**Silicate Bonding, “Ears”, Ribbon/Fiber
Status / Research and Development
Plan**

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Distribution of this document:
LIGO Science Collaboration

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1 Introduction

The Advanced LIGO Suspension System Conceptual Design (DCC T000012-00-D) calls for fused silica ribbons to be welded to fused silica “ears” which are silicate bonded to the flat sides of the penultimate masses and mirrors. In order to minimize suspension noise, ribbons instead of fibers are required as baseline suspension design for the ETM’s and ITM’s mirrors. The baseline material of these mirrors is sapphire with a fall back option of using fused silica.

The silicate bonding, “ears” and ribbon/fiber development needs to address both options.

This document summarizes the present status and the research and development on silicate bonding, “ear” and ribbon/fiber manufacturing and tests that we consider needs to be accomplished.

The development, manufacturing and test of the silicate bonding process, “ears” and ribbons and /or fibers are designed to reduce risk as the designs move forward into production.

The results obtained from these tests will be used to determine if the designs and processes meet the PDR and FDR requirements.

1.1 Note

Silicate Bonding: Bonding technique based on hydroxide-catalyzed surface hydration.

2 Near Term Research Plans to Fulfill PDR Requirements

We agreed that a bonding, ear and fiber/ribbon PDR could take place ~ September 2005

2.1 Silicate Bonding

Background

It is our understanding that the bonding procedure applied to GEO masses is adequate to fulfill Advanced LIGO requirements.

The bonding formula is based on commercially bought NaOH~14%, SiO₂~27% by weight (diluted 1:6 in DI water).

It is understood that the bonding technology, as it stands, has been transferred to Caltech. (Helena).

Caltech will perform the bonding on the noise prototypes, Glasgow will assist. Site personnel to observe.

Plan to fulfill PDR requirements:

1. Generate a silicate bonding procedure.
2. Perform long term strength tests on sapphire / fused silica bonds under load and increasing temperature.

2.2 Ears

Background

A baseline “ear” design exist and has been tested at GEO. This design will be used on the Adv. LIGO Mode Cleaner Noise Prototype.

Manufacturing procedures and strength tests have already taken place during GEO assembly, drawings exist.

Plan to fulfill PDR requirements :

1. Establish “ear” positioning tolerance requirements
2. Need to design fixtures to position “ears” in place during bonding procedure
3. Generate preliminary design drawings for “ears” to be used on Quad Noise Prototype

2.3 Fiber / Ribbon Development

Background

A proven technique of pulling, testing and welding cylindrical fibers exists and will be applied during the assembly of the Adv. LIGO Mode Cleaner Noise Prototype. Glasgow will take the lead on the task, Caltech to assist, site personnel to be present and observe.

Plan to fulfill PDR requirements :

1. Generate a manufacturing, welding and testing procedure for cylindrical fibers utilizing a CO2 laser.
2. Develop a repeatable manufacturing process.
3. Test strength
4. Design and test manufacturing fixtures
5. Coating of fibers to suppress un-wanted modes???

3 Long Term Research Plans to Fulfill FDR Requirements

3.1 Silicate Bonding

Background

The baseline bonding procedure has been developed and tested during PDR.

Plan to fulfill FDR requirements:

1. A 25+ kg sapphire test mass and a composite heavy mass (SF2) will be suspended in Glasgow to test the bonding process. (Helena to observe).
2. Caltech to perform the bonding on the Quad Noise Prototype; Glasgow to assist, site personnel to observe.

3.2 Ears

Background

A preliminary “ear” design for a QUAD Noise Prototype is ongoing. The first “ears” are to be manufactured and tested during the next 8-10 weeks.

Suspension in Glasgow of the 25+ kg sapphire mass will test “ears”, ribbon manufacturing and welding techniques. Additional weight may be added to the mass to reach 40 kg.

Helena to observe the procedure.

Plan to fulfill FDR requirements:

1. Finalize Quad “ear” design and drawings
2. Strength testing of bond between fused silica and SF2 to take place at Glasgow.
(A composite mass is being polished at this time for that purpose).
3. Complete the “ear” positioning fixture design to comply with the tolerance requirements established during PDR
4. Caltech to look into the possibility of performing noise measurements on sapphire/silica bonds under load and temperature increase. (TNI Proposal, LIGO-T040169)

3.3 Ribbon / Dumbbell Fiber Development

Background

We agreed on a Ribbon / Dumbbell Fiber Downselect date of April / May 2006.

Ribbons are considered “baseline”. If problems are not encountered during the testing of the heavy masses there is not a need to develop dumbbell fibers?

If development, manufacturing repeatability and strength tests on dumbbell fibers are needed, we have to establish how.

Tasks to be finished by April / May 2006

Plan to fulfill FDR requirements:

Applicable to ribbons and fibers

1. Measure “Q”, characterize profile on ribbons / fibers
2. Finalize ribbon manufacturing and attachment fixtures
3. Assess manufacturing and strength repeatability
4. Assess strength of welds
5. Generate testing and manufacturing procedures
6. Bond “ears”, weld ribbons on Quad Noise Prototype.
7. Design storage / transportation container for ribbons/fibers
8. Need to address manufacturing and welding of ribbons at LASTI.
Pulling and testing machine? Welding CO2 laser?