LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY

LIGO Laboratory / LIGO Scientific Collaboration

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Bonding & visual inspection of preliminary test ears (Serial Number 0001 – 0004)

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1 Introduction

Preliminary test ears for the ETM/ITMs were fabricated to drawing number D050169-06 for initial bonded ear strength testing and visual inspection. The ears are Heraeus Suprasil 2A and have a bond area of 1.77cm^2 in accordance with the allowable limit set by thermal noise considerations[1]. They are designed in such a way as to accommodate a lap welded ribbon. *Vendor 'B'* was commissioned to fabricate an initial batch of ten of these ears (assigned ear Serial Numbers: 0001 to 0010) for a series of preliminary tests.

This document describes the bonding of four of these ears (serial numbers SN 0001 to 0004) to silica discs (fabricated by *Vendor 'A'*) on 15th July 2005 by S. Rowan and J. Hough. The silica discs were manufactured to drawing number D050192-01 with ϕ = 50 mm and t = 7 mm.

Note: *Vendor 'A'* supplied Heraeus Suprasil 312 for these tests. However it was considered valuable to have data on Suprasil 2:312 bonds.

To allow for adequate curing of the bonds it was planned that bond strength testing would be conducted four weeks after bonding by C. A. Cantley and R. Jones during the visit to Glasgow of H. Armandula and J. Romie between 1st and 13th August 2005.

2 Bonding

The vial of silicate bonding solution used for the ears bonded on 14th July (Serial Numbers 0011 to 0014)[2] was re-centrifuged for 5 seconds. Four bonded sets were made using the ears supplied by *Vendor 'B'* (parts no SN 0001, 0002, 0003 and 0004) and flats supplied by *Vendor 'A'*. Materials are described in Section 1.

Before cleaning, the global flatness of each of the Vendor 'B' 'ears' was assessed using a Logitech LI10 interferometer as previously. The fringes appeared slightly curved.

Figure 1 shows an interferogram obtained with one *Vendor 'A'* ear (left) next to one *Vendor 'B'* ear (right). It can clearly be seen that the *Vendor 'B'* flatness is considerably poorer than the *Vendor 'A'* ear flatness, more like $\lambda/4$ than $\lambda/10$.

[1] Cantley et. al., *"Ear Bond Area Limit for ETM/ITM Optics from consideration of Thermal Noise"*, T050216-00-K

[2] Rowan, Hough, Cantley, *"Bonding and Visual Inspection of Preliminary Test Ears (Serial Number 0011-0014)"*, T050121-00-K.

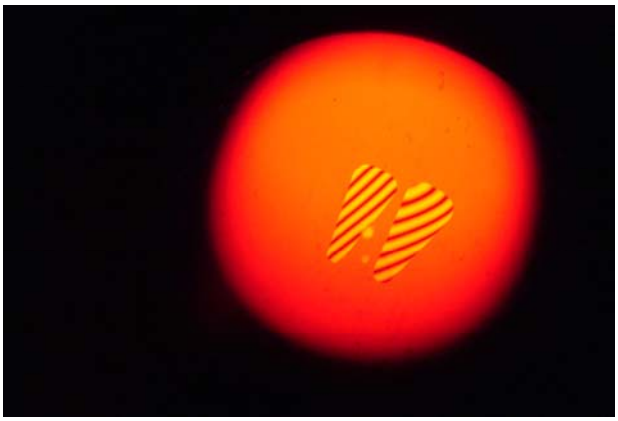

Figure 2. *Interferogram indicating flatness of 'as received' Suprasil 2 'ears' – one supplied by Vendor 'A' (left) and one from Vendor 'B' (right). The Vendor 'B' ear flatness is considerably poorer.*

The flatness of the silica discs (Suprasil 312) was also assessed before cleaning. Interferograms are shown in Figure 2.

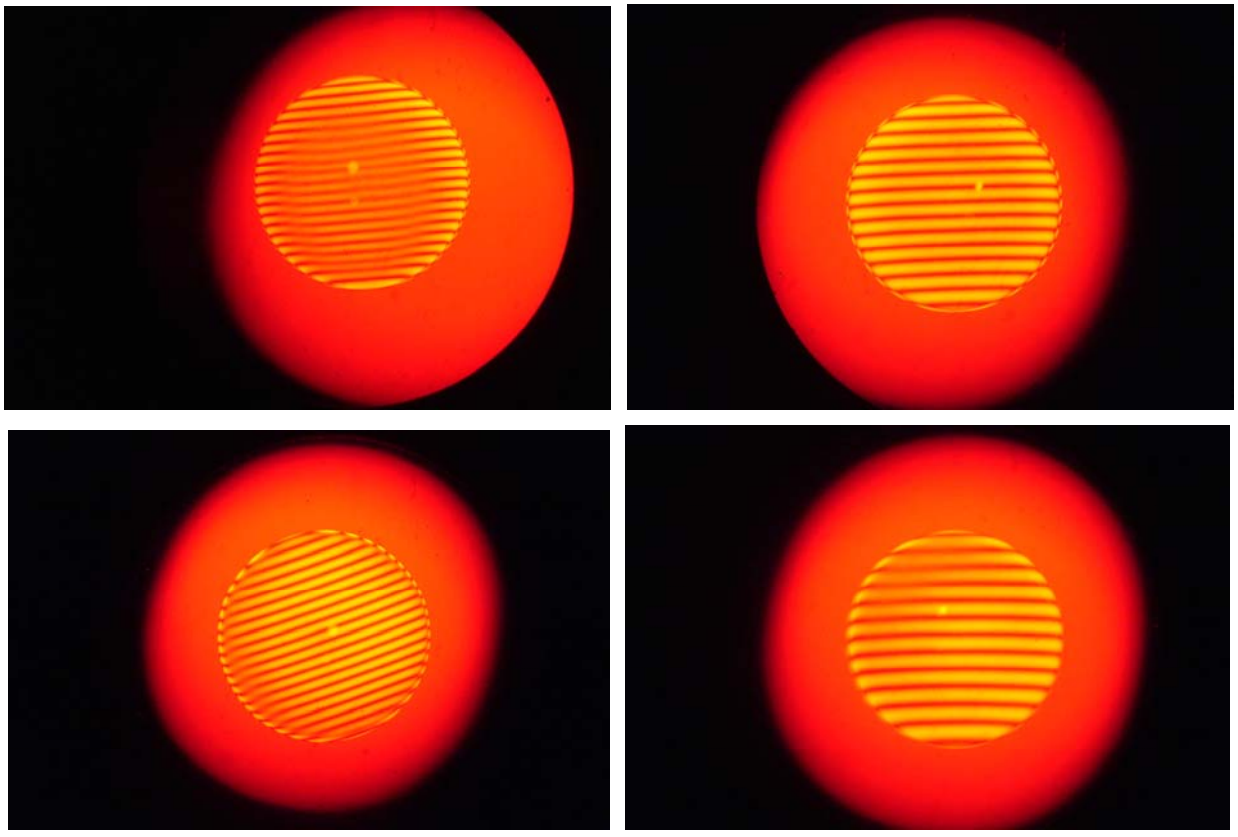

Figure 2 *Interferograms indicating flatness of 'as received' Suprasil 312 flats from Vendor 'A'.*

The ears and flats were all cleaned using the Advanced LIGO bonding procedure[3].

To bond each ear/flat pair the same procedure was followed:

- A single drop of 0.8 microlitres of bonding solution was dispensed onto the surface of a flat using a biological pipette.
- An ear was then placed by hand over the drop and lowered until it touched the drop and flat beneath with the drop spreading out to fill the entire bonding surface

Three of the four bonds showed essentially no fringes after ~10 mins. However the fourth set (SN 0001) still showed fringes over approximately half the bond area. (Note these were seen to diminish to an acceptable level after a few days as the bond cured).

All bonds were left on the clean bench to cure.

Additional Comments:

The specified flatness for the bonding surface on the ears was λ/10. Results show that the flatness was not as specified (more like λ/4). The other surfaces of these initial ears were specified as ground finish.

The ground finish was not ideal from two perspectives:

Bonding

1) the ground surfaces hindered inspection of the cleanliness of the polished bonding surface of the ear
2) the ground ear surfaces meant that the bonded interface could not be seen when the ear was put in place on the flat – so it was not possible to check that the bonding fluid had spread out correctly from above. However inspection could be carried out through the disc/flat after initial bonding.

Stress concentrations

3) Aside from causing visibility problems with respect to assessment of bond quality, it was considered that the ground finish could lead to undesirable concentrations of stress on the surface/edges of the ears when loaded. This was to be further investigated during loading tests on the bonded samples. It was considered that in these existing bonded test ears the surface quality could be improved by flame polishing. Future ears would be fabricated with an inspection polish to remove this problem.

[3] Armandula, *"Silicate Bonding Procedure (Hydroxide-Catalysis Bonding)*, E050228-00-D