LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY

LIGO Laboratory / LIGO Scientific Collaboration

LIGO-T1000006-v6 *LIGO* March 23, 2010

Notes on Making Electrical Connections to Metalized Crystals & Test Outline for ESD Samples

Margot Phelps, Eric Gustafson and Dennis Coyne

Distribution of this document:
LIGO Scientific Collaboration

This is an internal working note
of the LIGO Laboratory.

California Institute of Technology
LIGO Project – MS 18-34
1200 E. California Blvd.
Pasadena, CA 91125
Phone (626) 395-2129
Fax (626) 304-9834
E-mail: info@ligo.caltech.edu

Massachusetts Institute of Technology
LIGO Project – NW22-295
185 Albany St
Cambridge, MA 02139
Phone (617) 253-4824
Fax (617) 253-7014
E-mail: info@ligo.mit.edu

LIGO Hanford Observatory
P.O. Box 1970
Richland WA 99352
Phone 509-372-8106
Fax 509-372-8137

LIGO Livingston Observatory
P.O. Box 940
Livingston, LA 70754
Phone 225-686-3100
Fax 225-686-7189

http://www.ligo.caltech.edu/

1 Introduction

In this revised version of T1000006, I have merged Gustafson's comments with my proposed outline for the ESD sample tests(Phelps). Gustafson talked to people at half a dozen companies about how they make electrical contacts to electro-optical and acousto-optical modulator crystals, Silicon die for electronic components and SIO die for MEMS and came up with 6 techniques. The techniques include conductive epoxies (including silver epoxy), Indium soldering, a combination of silver epoxy tacking followed by Indium soldering, clamping, wire bonding, and laser welding. In all of the techniques the wire is attached to a gold pad evaporated onto the surface of the crystal. Copper, Nickel and/or Chrome are usually used to improve the gold adhesion. As of Feb. 25th CSIRO has not decided on a coating thickness.

2 Test Outline:

Each alternative way of making ESD connections will be tested for mechanical and electrical strength. A multimeter will be used to test the resistance of the connection to determine the quality of the electrical connection. A 500g force scale will be used to test mechanical strength, both parallel and normal to the surface.

2.1 Conductive Epoxy

A. Tra-Duct silver epoxy: #2902 approved for LIGO restricted use (see LIGO-E960050) Tra-Con was bought by Henkel and is moving production to China, so until I can get some Tra-Duct I will be using two silver epoxies from Allied Electronics, one type is MG Chemicals and the other CW2400, for testing purposes.

Gustafson notes: One person warned that Silver epoxy can polarize creating in effect a bad Shottke diode.

2.2 Indium Solder

A. Old ESD procedure: LIGO-T1000041
B. New technique: Indalloy ™.http://www.indium.com/ Eric's loop of wire technique?
C. Use a de-soldering station instead of a solder gun. This may result in a lower, more manageable temperature & easier procedure , will use an IR thermometer to see.
D. vacuum melting indium to gold coating: LIGO-P720001-00

Gustafson notes: It is not uncommon to use a loop of copper wire wrapped around a soldering iron tip and clipped with a pair of diagonal pliers to produce a sharp point. For reproducibility and ease of use a preform is often used. There is a lot of technology here and

Dennis Coyne 1/8/10 11:45 AM
Comment: I don't understand how this loop is used and what the sharp point is for. Please amplify.

we would have to get up to speed on what is best for us. The low temperature solders are used for two reasons. First, crystals like PZT, Lithium Niobate, KDP and ADP can fracture during soldering due to thermo-elastic stresses resulting from non-uniform heating. I don't know how the fracture toughness of glass compares to crystals for processes like these. Second, the Indium solder step is often the last in a series of soldering steps involved in producing electrical connections and hermetic seals with progressively lower and lower temperature solders.

2.3. Silver epoxy followed by indium soldering

Try a combination of silver epoxy to tack the wire to the gold pad followed by Indium soldering for strength. (Although it is not recommended to solder silver epoxy, it may work)

3. Alternatives

3.1 Wire Bonding

Conundrum of wire bonding: Wire bonding is widely used in the MEMs industry, so there is bound to be enough information out there for us to develop a good wire bonding technique. However, it has the downside of requiring a large, specialized machine, retailing at $10,000-$15,000 used(Gustafson). I will investigate "portable wire bonders" but I'm pretty sure they don't exist. The connections are apparently very good once done, but as Calum has pointed out, in the event that they did break we would have no way to repair them in situ. So for now I will focus on the conductive epoxies and indium solder methods.(Phelps)

Gustafson Notes: Wire bonding uses a machine to attach a wire to a gold pad on a substrate. The bonding is created by a combination of vibration and force to "scrub" the interface between the wire and the substrate producing a localized temperature increase and bonding by diffusion. Often the substrate is heated to between 100 and 150 C to increase the diffusion further. Usually the substrate is made of silicon and we would probably have to develop a process that would work with glass. The operator usually watches through a microscope. A typical pad might be 500 angstroms of Inconel and 1000 angstroms of gold, close to our coating thicknesses (see for example E0900112). The wires can be up to 20 microns in diameter. A flying head can be used to pull away a wire several centimeters long. There are bonders that can use gold ribbons or multiple wires to carry larger currents. Manual (used) wire bonders typically cost between 15 and 35 k$. Hans Lindberg at Hybrid Inc. (760.746.7105) was very helpful. A history of wire bonding is at http://nepp.nasa.gov/wirebond/Basic%20Info.htm.

3.2 Gold paint, or gold leaf

If the vapor deposited gold pads are too thin for soldering reliabily, one could consider increasing the thickness of the gold for the pad. Indium corporation has had success with gold paints (see P720001-00) which are likely rather thick. Alternatively gold leaf (foil) could be applied with pressure.