Use of Galinstan as a Contact Agent for Additively Manufactured Components in Cryogenic Engineering

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Abstract

We introduce a new, demountable, brush-on thermal interface material for cryogenic applications. A process has been developed that allows to removably provide contact e.g. between an **additively manufactured component** and its interface. The use of Galinstan as an industrial material for cryogenic applications and in particular for those materials used in additive manufacture is reviewed and explained. Thermal contact conductance values are also presented for dissimilar materials, that have not been investigated before.

1. Introduction

Whenever one has to design cryostats or cryogenic components with interfacing surfaces (e.g. cryocooler/cold plates) one needs to carefully consider multiple design constraints, e.g. minimum contact resistances, high bonding strength etc. Additional design and assembly complexities arise when we intend to separate those components from each other and in particular when those components tend to be of delicate structure, e.g. a heat switch. Interface separation usually requires removal of the component by de-soldering interfaces at high temperatures, de-brazing or de-bonding or generally breaking the contact with heat guns or other more invasive methods, etc.

Although this is possible in case the component can be removed easily, the latter is more the exception from the rule. Normally we deeply embed contacts within the cryostat so that we do not have easy access to the component. Warming up the complete cryostat much above room temperature just to break the contact the component is in contact with is hardly feasible in most cases.

In the following we show the quest for the best contact means for one particular cryogenic component that can be separated by warming up the respective interfaces well below room temperature and without applying any mechanical force.

2. Why Galinstan ? – Summary of Constraints

- Additive interface of dissimilar materials with different CTEs (see Figure 2)
- Choose a filler with high thermal conductivity
- Ideally, the material should be suitable for “industrial use” applications
- ΔT between the two mating surfaces should be below or equal to 0.1 K
- No thermal cycling effect on the thermal contact conductance
- No contact pressure should be applied to the interface and the mating parts
- The thermal contact surfaces should be able to recover from “hot” service temperature shocks without degradation, whereas the shocks can occur over 30 minutes, however without reaching RT
- Occasionally, it should be possible to completely break the surface contacts without exceeding RT at the contacts after a cryostat insert warmup
- Simple process of applying the interposing filler material onto a surface
- Break contact safely at RT without any surface damage on both mating parts, maintain the same thermal contact conductance
- Chosen interposer/filler should not be affected by usual, technical and commercial surface roughness or non-perfect parallel surfaces
- The chosen material should be inexpensive
- Material used needs to be RoHS compliant

3. Bond strength estimate of solid Galinstan interfaces

We used a copper dumbbell with a diameter of 1 inch, following the procedure as shown in Figure 1.

How to do it

- ❑ Remove any visible oxide layer on both surfaces with fine grit non-woven abrasive pad and brush apply Galinstan at both surfaces
- ❑ Apply light, soft pressure to surfaces to expel air, remove flare using a syringe
- ❑ Place assembly into a Styrofoam container and pour liquid nitrogen in a separate Styrofoam container
- ❑ Pour over sample thus cold shocking the complete assembly
- ❑ Continue fill until sample is immersed fully in nitrogen bath and wait until no bubbles are seen indicating the assembly has assume LN_2 temperature
- ❑ Take out of container, apply force on copper rod.
  Both surfaces cannot be separated manually.

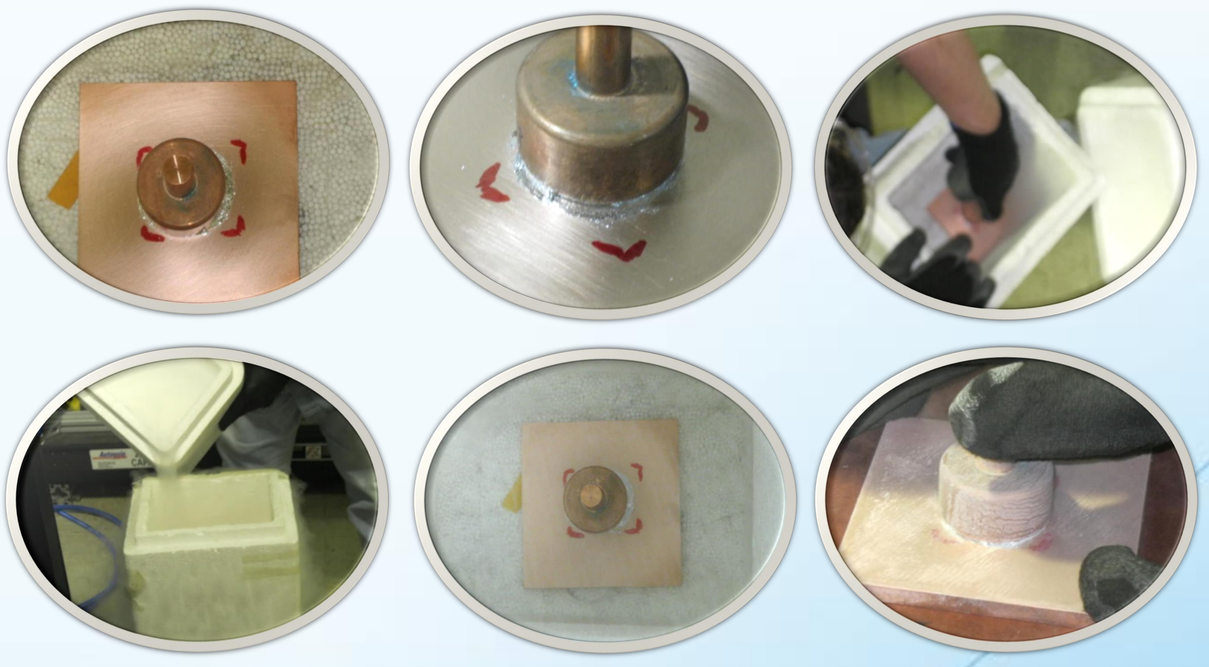

Figure 1: Copper samples Galinstan brush-on

4. Bond test results with different materials and Galinstan as interposer

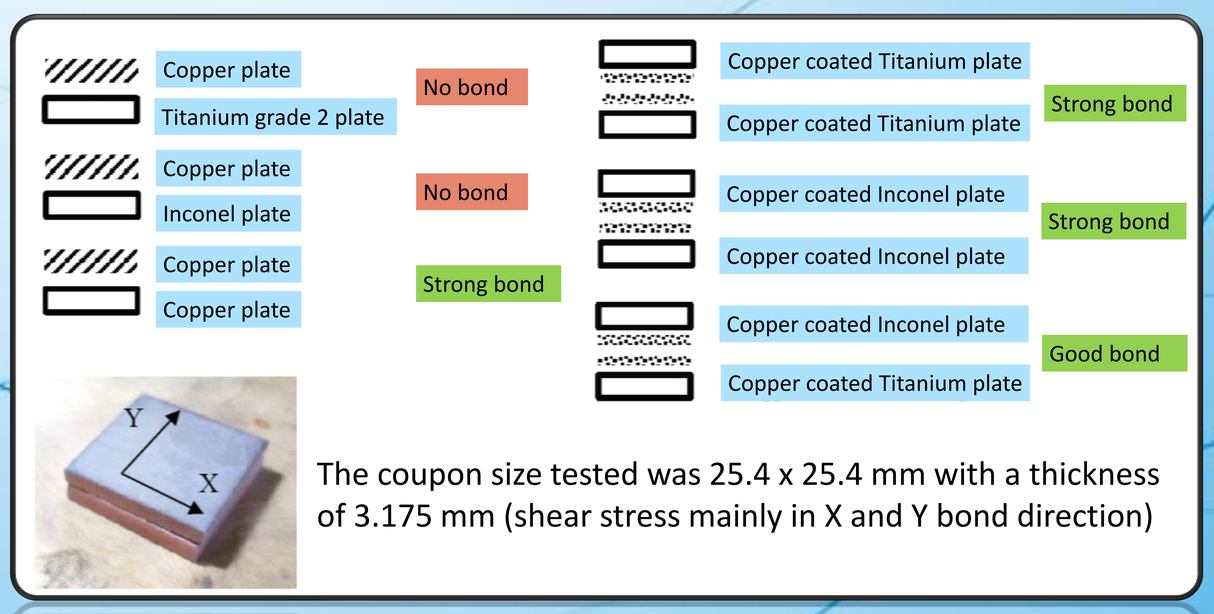

Figure 2: Bond test of typical surfaces for materials commonly used in additive manufacturing