Indium bonding of magnets to aluminum flags

We developed a way of joining the magnets to their aluminum holders and flags by cold welding.

Cold welding is the joining of two nonferrous metals under pressure without the use of heat.

The surfaces have to be well prepared, free of an oxide layer, and the pressure should be sufficient to produce 35% to 90 % deformation at the joint necessary to break the oxide layer and expose a fresh metal to make contact.

Indium does not wet aluminum readily, so, extra attention should be given to the aluminum surface preparation.
To enhance the adhesion of indium to aluminum, first we clean the aluminum surface by ultrasonically cleaning it in ethanol or any other solvent. Next, we blow dry with dry nitrogen and etch the surface to be exposed to indium with a 50% hydrochloric solution. As soon as the surface starts reacting with the acid we allow it to work etching the aluminum for about 3-4 seconds. Then, we rinse thoroughly under running DI water and blow dry.

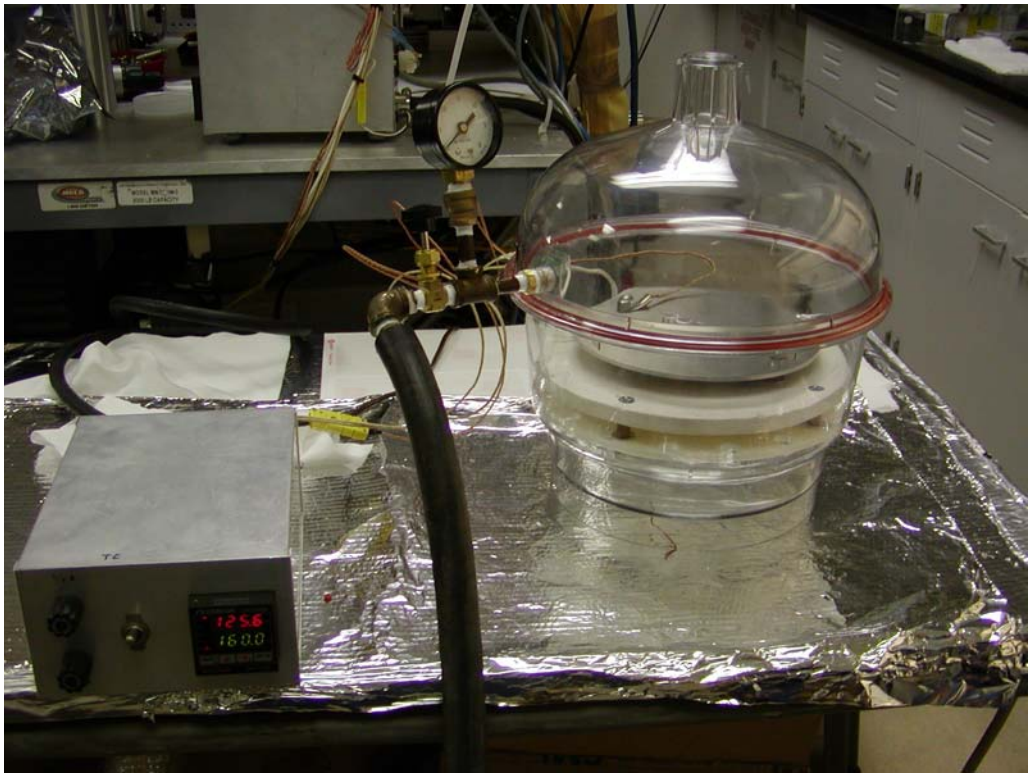
We prepare indium disks from a 0.001" thick indium ribbon, 4 N's is the purity required. Clean the indium with ethanol and /or acetone to prepare the surface for etching. Once the surface is oil free, etch each disk individually until the surface shows a reaction with the acid. Rinse thoroughly with DI water. Dry with acetone.

Place the indium disk over the freshly cleaned aluminum surface. By using a block of Teflon previously cleaned, press the indium against the aluminum surface.

After a number of parts have been prepared in this way, we place the parts in a vacuum vessel, pump down and heat the aluminum parts until the indium melts (~135° C). Shut off the heat and allow the parts to cool.

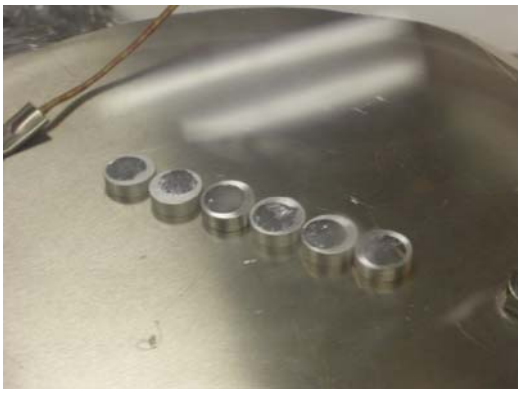
Magnets are cleaned in a similar fashion, first, clean with a solvent, then, etch a few minutes and rinse thoroughly with DI water. The Neodymium Iron Boron (NdFeB) magnets are nickel plated with a very thin layer of copper under the nickel.

When the parts are ready to be jointed, with a clean razor blade we scrape the top of the indium melted on the aluminum surfaces to remove the top oxide layer, align the parts with the freshly cleaned magnet. Verify alignment and press the parts with an arbor press.

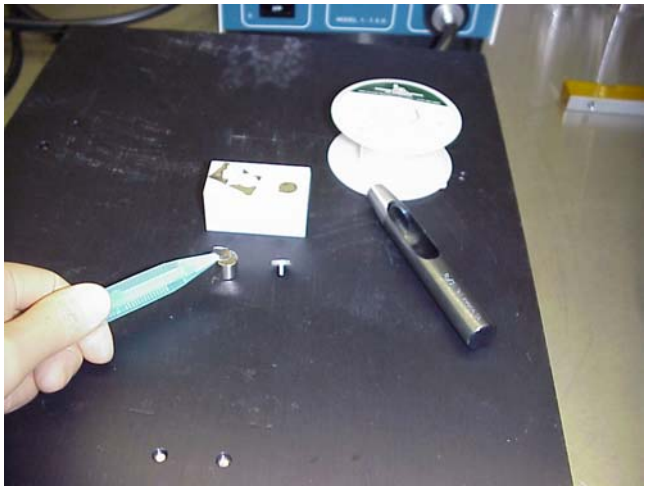


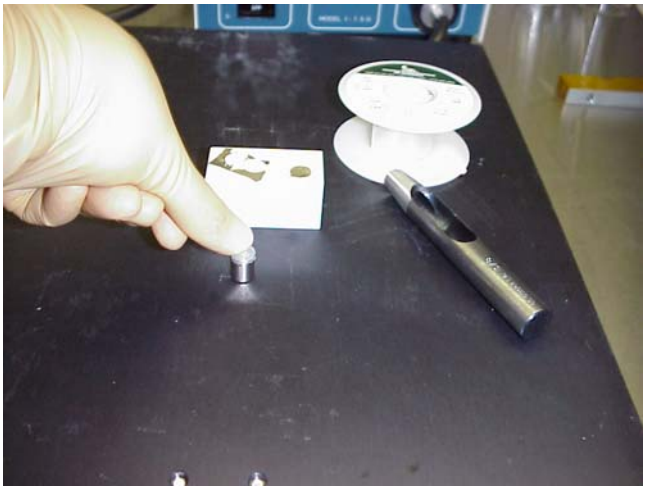
Vacuum vessel (courtesy of Robert Taylor-40m Lab.)

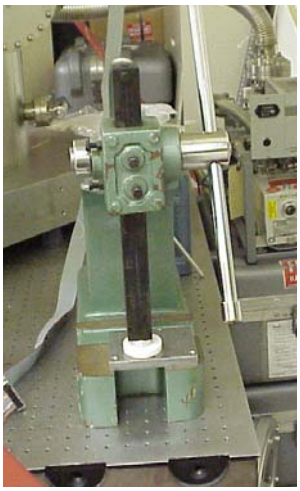
Indium before melting

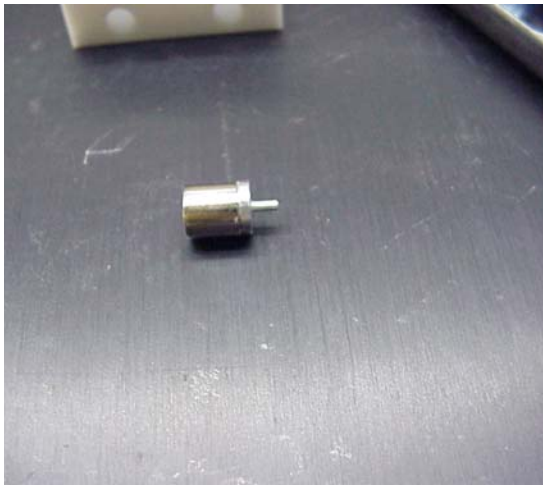


Indium after melting









Even when these bonds will not be subjected to any stress other than an accidental knock, we tested the strength of the bond in shear with a 2 kg weight for 3 hours without detrimental effects.