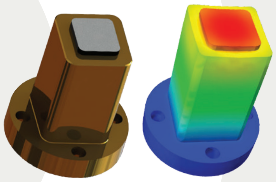
NINE THINGS YOU NEED TO KNOW

USER GUIDES: SAMPLE MOUNTING

Suppose you need to attach a sample to a mount that attaches to a cold finger. There are two interface layers to consider, plus the mount geometry. Here are nine things to keep in mind as you mount your sample:



1

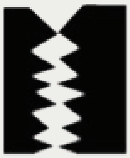
Think in terms of **CONDUCTANCE**, or heat flow per degree, which depends on boundaries, geometry, and materials of all the elements. A good rule of thumb is that your conductance should be about 1 Watt/Kelvin for each part geometry and each boundary. You can look at this as a chain, where the heat transfer is as strong as its weakest link. Try to achieve the 1 W/K between any two points in your heat flow path.

2

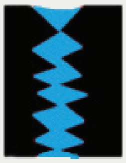
MATERIALS – Specify C101 (also known as OFE or OFHC) copper for good conduction of ~630 W/m*K at 4K. Never use aluminum or any steel. Both can have conductivities less than 6 W/m*K at low temps. Even standard grade copper (C110) is than less than 300 W/m*K.

3

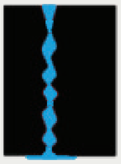
SURFACE QUALITY – Make sure your surfaces are smooth – spec a surface roughness of 0.8um Ra. You want the mating surfaces to contact completely. The images below show how surface roughness (exaggerated) affects effect contact area and how thermal grease (shown here in blue) can improve it:



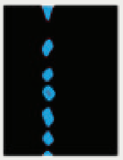
Rough boundaries = poor contact



Grease filled boundaries = not great



Smooth greased surfaces = good



Smooth greased pressed surfaces = best

4

GOLD - Gold coat any mating surfaces. This reduces oxidation and gives you a compliant surface that will deform under pressure and increase your contact area. 1-2 microns is a good thickness. Coat the whole part, because as copper oxidizes, its emissivity rises substantially and this leads to heat losses.

5

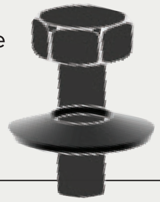
PART GEOMETRY – As you design your mount, pay attention to your design target of 1W/K. For an individual component this is:

$$\textbf{Conductance} = Q / (T_2 - T_1) = -k * A / L$$

Maximize the cross sectional areas, A, and minimize the path lengths, L. Design the post area at least as big as your sample in cross section. This assures that you are in contact with the full sample area for heat flow. Also minimize the distance from the sample to the cold finger.

6

PRESSURE – If you have a way to apply force, then do it. In fact, having connections using force is more important than actual contact area. For example, a good bolted connection has a conductance of about 10W/K at each bolt! And four bolts are much better than two. You will also need to maintain contact pressure over the full temperature range. If you are bolting over a long distance (10+mm), consider using brass bolts, as brass contracts more than copper as it cools, so your connections tighten up. If you are bolting a short distance(<2mm), use stainless steel bolts, because they are strong and any material contraction is less than the bolt stretch. Another good option is to use Belleville washers, as they apply force over a length range and they can be stacked. Beware that Indium at boundaries will cold creep, requiring bolts to be retightened after each thermal cycle.



7

THERMAL GREASE – Keep it as thin as possible. For example, N grease has a conductivity of about 0.1 W/m*K, which is pretty poor compared to your copper. So keep it thin. If you can't use bolts, use VGE (GE varnish), but keep the layer very thin. Here's a practical trick: To mate two surfaces, use a drop of acetone on one surface, a small drop of VGE on the other, squeeze them together, then let it sit under pressure until dry. This makes a strong and thin adhesive layer that can be removed with acetone later.

8

RADIATION LOADS – Watch your radiation losses as heat is transferred to your sample. This can often be every bit as important as your mounting. But that is a topic for another guide. For now, try to have an intermediate shield at 40K that blocks the radiation from room temperature from hitting your sample and avoid any holes in that armor.

9

WIRING LOADS – If you have any wires going to your sample, they will act as a heat pipe straight to your sample. Again, this is a topic for another day. For now, make your wires long and thin and carefully routed.

This will be the topic of our next user guide, so stay tuned!

If you pay attention to these details in your sample mounting, your sample will stay connected and close to your cold finger temperature. Good luck on your research! If you're a veteran to the field and want to share your tips for optimizing a thermal connection, send us an email; we'd love to hear from you!

Montana Instruments makes closed cycle optical cryostats which can keep your samples at 3K. If you'd like to find out more about us, visit our web site: www.montanainstruments.com (406) 551-2796

MONTANA INSTRUMENTS
COLD SCIENCE MADE SIMPLE