1x2 Thermal Mockup Assembly

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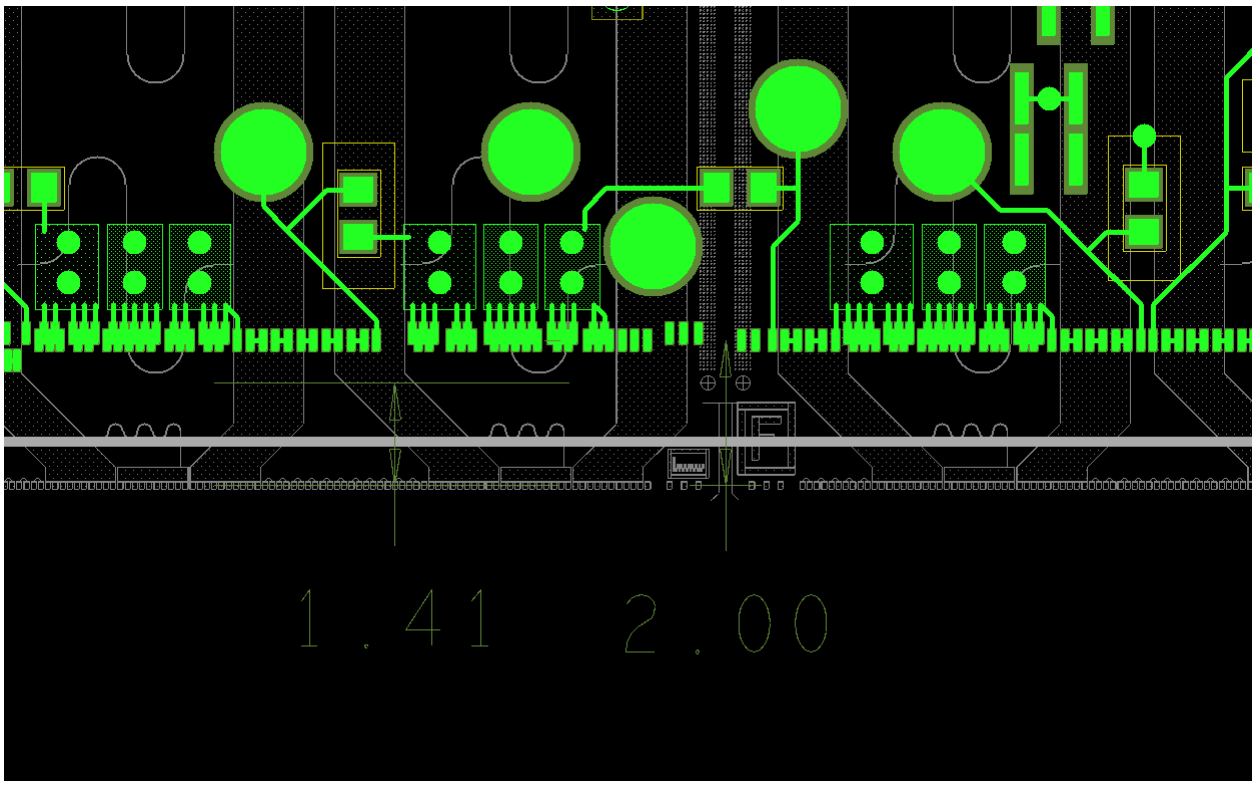
Assembly of 1x2 thermal mockups proceeds by placing an HDI on the launch pad, and surveying the bond pad locations to calculate a point on the bond pad axis. This point defines the origin of a coordinate system along the shimmy/slide axes and is relocated to any of the five assembly chucks. The fiducial markers on a 1x2 heater are then surveyed to locate a point on the heater which will be positioned relative to the point on the HDI when the whole stack is placed on the assembly carrier.

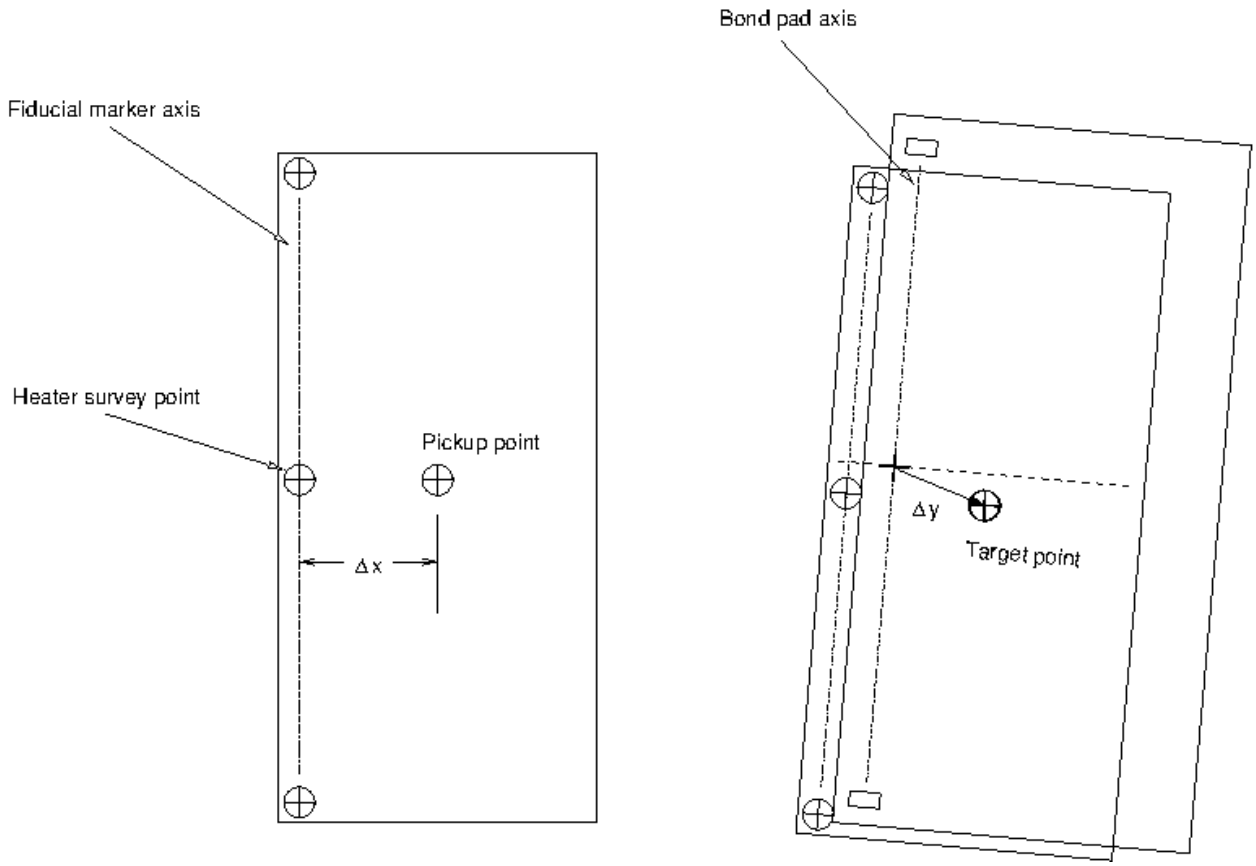


The fitted point on the HDI lies on the line along which most of the bond pads are placed and is named $hdi_point. The fitted point on the heater is on the line along which the fiducials are located and is named $heater_point. The point at which the heater is picked up is located $\Delta x = 8\,mm$ to the right of this point, perpendicular to the fiducial axis.

The position of the HDI point on the target assembly chuck is named $new_hdi_point. The heater drop point is located relative to the new HDI point, offset by a distance $offset_dx. For example, when $offset_dx = {7.5,0,0}, the drop point will be located 7.5 mm to the right of the line of bond pads. The bond pads on the heater are located 1.41 mm to the left of the fiducials,

so this would place the HDI bond pads and the heater bond pads on lines that are separated by (8 mm - 7.5 mm + 1.41 mm) = 1.91 mm.

Here are the details…



The surveyed point on the HDI when located on the HDI launch pad is $\vec{x}_i$ and the unit vector along the bond pad axis is $\vec{u}_i$. When moved to an assembly chuck, the new point will be located at

$$\vec{x'}_i = \vec{x}_c + R(\Delta\theta)(\vec{x}_i - \vec{x}_h)$$

where $\Delta\theta$ is the change in angle when moving to the assembly chuck, $\vec{x}_h$ is the location of the top (round) pin on the HDI launch pad, and $\vec{x}_c$ is the location of the top pin on the assembly chuck. Likewise, the new unit vector $\vec{u'}_i$ along the bond pad axis is determined by rotating $\vec{u}_i$ by the additional angle $\Delta\theta$. The point on the heater, when placed on the launchpad, and the unit vector along the line of fiducial markers are $\vec{x}_j$ and $\vec{v}_j$. The angle that the heater needs to be rotated, to match the orientation of the HDI on the assembly carrier is

$$\Delta\theta_j = \theta_i + \Delta\theta - \theta_j.$$

which ensures that the bond pad axes are parallel.

The heater is picked up at a point displaced from the surveyed point by a distance Δx so that the suction cups make contact near the center of the heater. The target point on the heater is specified relative to the survey point on the HDI by a displacement $\vec{\Delta y}$. The displacement $\vec{\Delta y}$ is calculated so as to achieve the desired alignment of the bond pads on the assembled module but can be adjusted to absorb systematic deviations.

Initial Setup

1. Ensure that all the parameters determined from the Initial Gantry Survey, GHCO Calibration, and Chuck Offset Calibration scripts have been loaded correctly. This should be automatic if read from the flex-config file, but will have to be hard coded if not.

2. Set the initial drop correction parameters to zero:

   COPY $drop_correction {0.000,0.000,0.000}
   COPY $drop_rotation 0.000

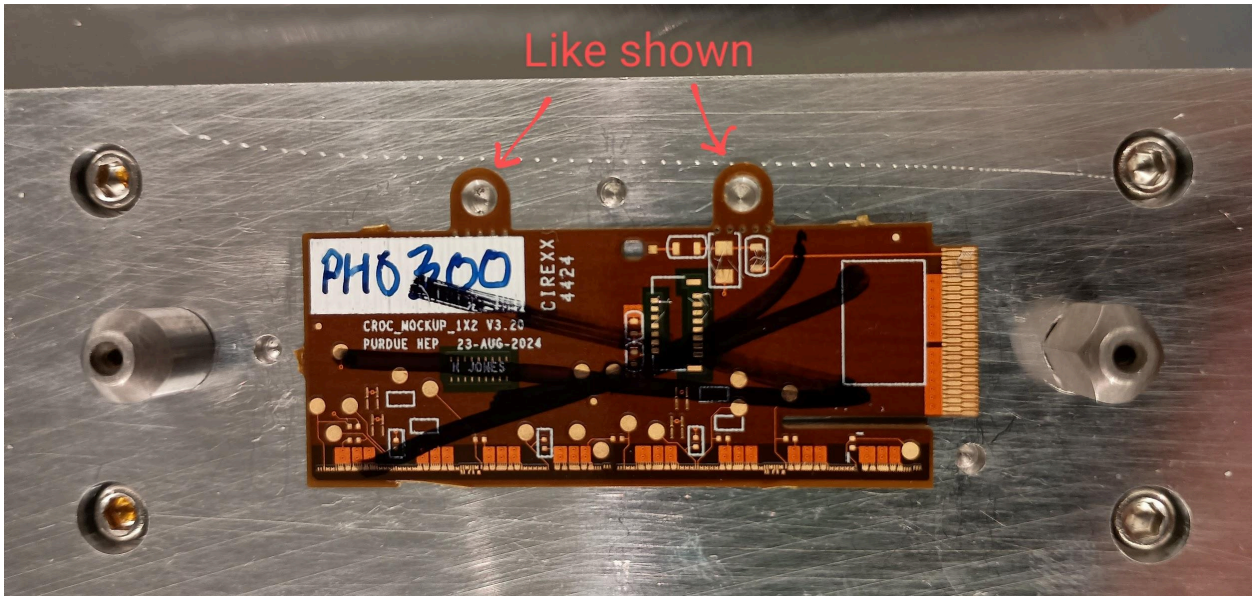
3. Set the initial slide component of the chip position vector to zero:

   COPY $offset_dx {$offset,0.000000,0.000}

Procedure

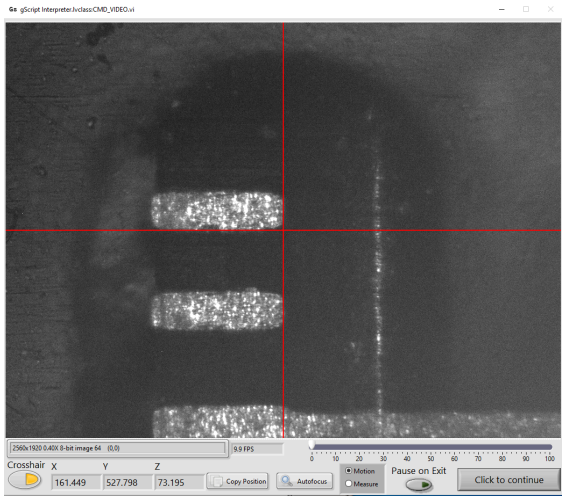
1. Select an HDI and a 1x2 thermal mockup heater for assembly. Run the ‘Assemble_1x2_Mockup’ script.

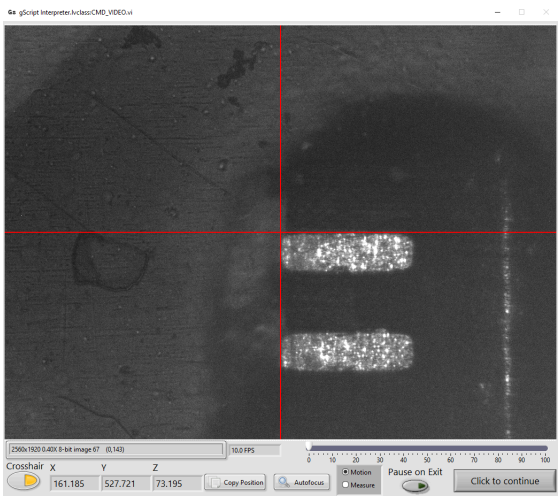
2. When prompted, place the HDI on the launch pad. It needs to be aligned so that the mounting holes line up with the alignment holes on the launch pad as shown:



3. Select one of the HDI pickup tools. When prompted, specify which pickup tool is used, and place it on the HDI. The vacuum will then be transferred to the HDI pickup tool.

4. Survey the bottom-right and top-left corners of the four bond pads as shown:



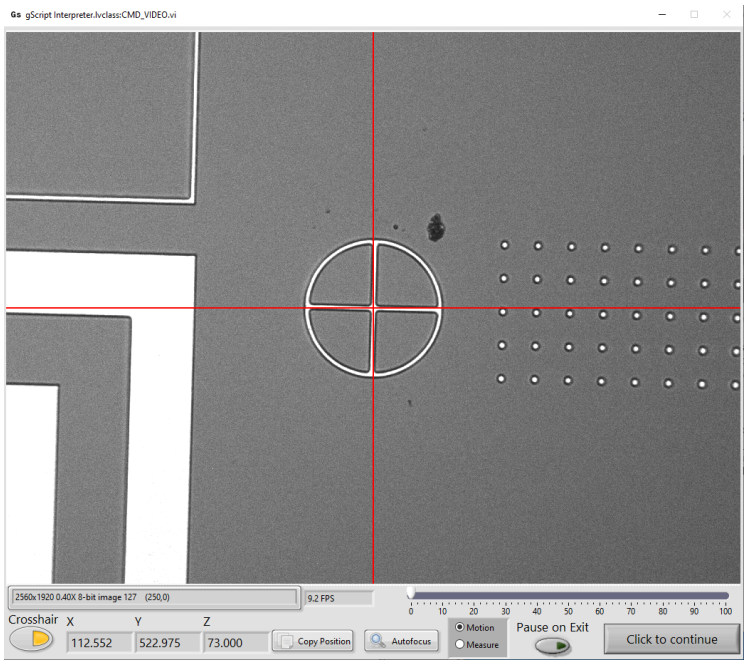


Repeat this step for all four bond pads. If the bond pads are too far away from their expected nominal positions, then the glue stencil will not align correctly. If this is the case, the script will warn you that the HDI is badly misaligned. This can be ignored if you don't intend to use the glue stencil, but if the module is intended to be glued, then be sure you understand the implications of ignoring this warning.

5. When prompted, place the 1x2 thermal mockup on the chip launch pad. Its initial location and orientation are controlled by the $chip_offset and $chip_angle variables. We use Kapton tape as a stop to define the initial position of the heater and these

variables facilitate finding the fiducials in their expected locations. They can be updated for convenience at other assembly sites.

6. Survey the four fiducials on the heater:



7. Next, when prompted, the camera moves to the middle of the part and the height of the surface that will be used to pick it up will be measured. This is not so critical for the thermal mockup since this surface is the same height as the fiducials, but for sensor-ROC assemblies, this surface will be higher than the fiducials by the thickness of the sensor. It needs to be measured to control the force of the suction cups on the sensor surface when it is picked up.

8. The part is now ready to be picked up. When prompted, the gantry loads the picker tool and picks up the heater.

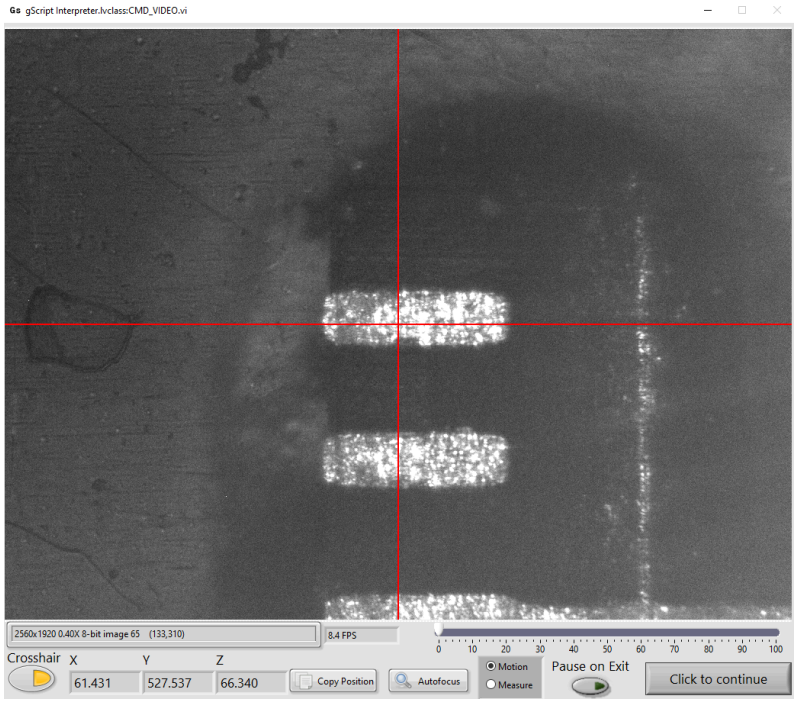
9. The script asks which assembly chuck to use. Make sure there is an assembly carrier on the selected chuck. Once the chuck has been selected, the part is lowered into position, rotated to match the expected orientation of the HDI, and slowly placed on the assembly carrier where it is held in place with vacuum.

10. Next, survey the locations of the fiducials on the placed part. The camera moves to their expected locations and any deviation from these positions is used to calculate the new drop correction for the part. The drop correction converges after a few iterations. Here are the results from several dry runs at Purdue:

	DC.x (mm)	DC.y (mm)	DC.r (deg)	Δx (mm)	Δy (mm)	Δr (deg)

1	0.000000	0.000000	0.000000	0.009016	-0.005060	-0.002812
2	0.009016	-0.005060	-0.002812	0.002913	-0.000267	-0.005655
3	0.011929	-0.005327	-0.008467	-0.000269	-0.000003	-0.001408
4	0.011660	-0.005330	-0.009875			

11. Place the HDI on the assembly chuck and then follow the prompts to survey the locations of the bond pads. The camera moves to the expected bond pad location. If the chuck offsets have been measured precisely, then the camera will be looking at the center of the bond pad. If not, the deviation can be used to correct the chuck offset. This picture shows that the pad is slightly too high in y and is slightly to the right in x:



Click on the center of the pad to calculate the updated pin location. The script will suggest an updated location for the top pin on the assembly chuck. If the size of the correction is significant, then the pin location should be updated. However, deviations from the surveyed pin position should be small, of the order of 10 um. If they are significantly larger, then something must have gone wrong.

12. Next, the placement accuracy of the assembled module is measured using the 'Survey_1x2_mockup' script. Load the script and run it.

13. The script first asks if you want to turn off the vacuum on the HDI pickup tool. If the part has been glued and the epoxy cured, then it is a good idea to remove the HDI pickup

tool before surveying the placement accuracy. Specify which HDI pickup tool is used, and the vacuum is turned off. For dry runs you can leave it on and keep the HDI in the same position on the pickup tool for subsequent assembly runs.

14. The survey script needs to know which assembly chuck to find the module to be surveyed on. Select an appropriate chuck.

15. When prompted, align the camera with the center of the HDI bond pad and the center of the corresponding pad on the heater.

16. Based on the positions of the bond pads on the HDI and the heater, the shimmy and slide are calculated and compared with the nominal geometry for each wire bond.

17. As the last step, you can either turn off the vacuum on the assembly chuck, or leave it on.

The average slide can be adjusted using the y-component of the $offset_dx variable in the assembly script. However, the slide will be completely correlated with the location of the top pin on the assembly chuck. To separate these contributions, it is necessary to perform dry runs on all five assembly chucks with $offset_dx held fixed. The results from one such study at Purdue are shown here:

Chuck	$offset_dx.y (mm)	Pin Δy (mm)	Avg slide (mm)	Residual (mm)
0	0.000000	0.000000	-0.019475	-0.019475
1	0.000000	-0.017034	-0.034996	-0.015521
2	0.000000	-0.010115	-0.029271	-0.019156
3	0.000000	0.000000	-0.020681	-0.020681
4	0.000000	-0.011708	-0.030585	-0.018877

The residual is the difference between the average slide and the suggested correction for the top pin position. You can see that after subtracting the contribution from the pin, the residual is approximately constant with an average value of -0.018742 mm. When the pin locations are updated with the recommended corrections and $offset_dx.y is set to -0.018742 mm, the results from dry runs on all five assembly chucks looks like this:

Chuck	$offset_dx.y (mm)	Pin Δy (mm)	Avg slide (mm)	Residual (mm)

0	-0.018742	0.000000	-0.001819	-0.001819
1	-0.018742	0.000000	0.000354	0.000354
2	-0.018742	0.000000	0.003597	0.003597
3	-0.018742	0.000000	-0.001233	-0.001233
4	-0.018742	0.000000	0.002681	0.002681

The average residual is now 0.000716 mm and individual measurements are consistent with statistical fluctuations at the level of about 2 um.

In fact, the offset is consistent with the expected offset once taking into account that the 1x2 thermal mockup HDI manufactured by Cirexx is slightly smaller than the design. On this HDI, bond pads 1 and 4 are spaced by 43.067 mm rather than the nominal 43.100 mm as designed. If the heater is aligned so that the slide of pad 4 is 100 um, then the surveyed point on the fiducial axis and the point on the HDI are displaced by -0.0165 mm which seems to be quite consistent with the deduced value of -0.0187 mm given the size of the remaining statistical uncertainties.