Description: 2S Module Assembly Procedure - Sensor Gluing

Document Category: Procedures

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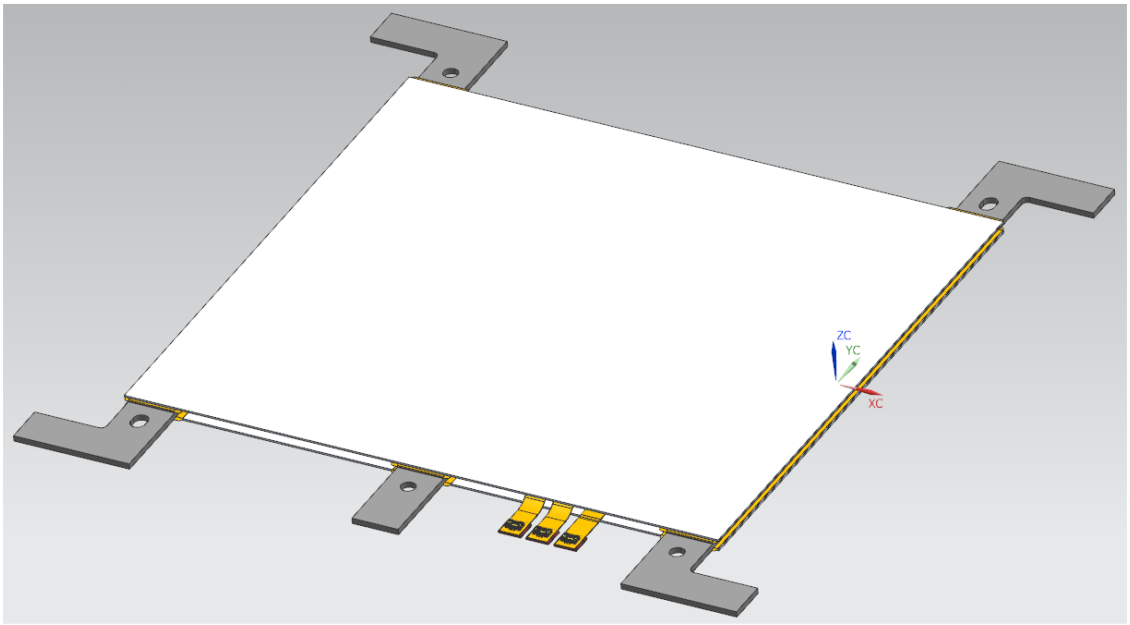
Fermilab

INTRODUCTION

This procedure describes the process of assembling the mated pair of sensors, as represented in the CAD model F10140413[1]. It is based on the process developed by Alan Honma et al. documented in the CERN espace area[2] with customizations (mainly the edge pin design) and added images where appropriate.

Angular alignment between the top and bottom sensors is important, with an allowable limit of 400urad, which corresponds to about 37 microns over the length of the sensor edge with the wirebond pads. The sensor subassembly is to be made from a top and bottom sensor assembly (each equipped with Kapton isolators and a bias voltage tab) with two main bridges and either one or two stump bridges, depending on the flavor of module being assembled.



PRECAUTIONS

The module subassembly is both physically fragile and sensitive to ESD damage. The following precautions below should be observed whenever directly handling modules. Handling of modules on their carrier plates during electrical testing is addressed separately in the procedure relating to testing. Observe the following precautions when working with Tracker modules:

- All team members who handle modules shall have up-to-date Electrostatic Discharge Training (Fermi # PDSI0001/CR/01 or equivalent)
- A grounded wrist strap shall be worn
- Lab D cleanroom work requires wearing a hair net, shoe covers, and an ESD-safe labcoat

[1] Fixture CAD model and drawing PDFs available in https://edms.cern.ch/document/2770156

[2] https://espace.cern.ch/Tracker-Upgrade/2S-Module/Shared_Documents/2S%20Module%20Assembly%20Steps/2S_module_assembly_steps_20190612.docx?Web=1

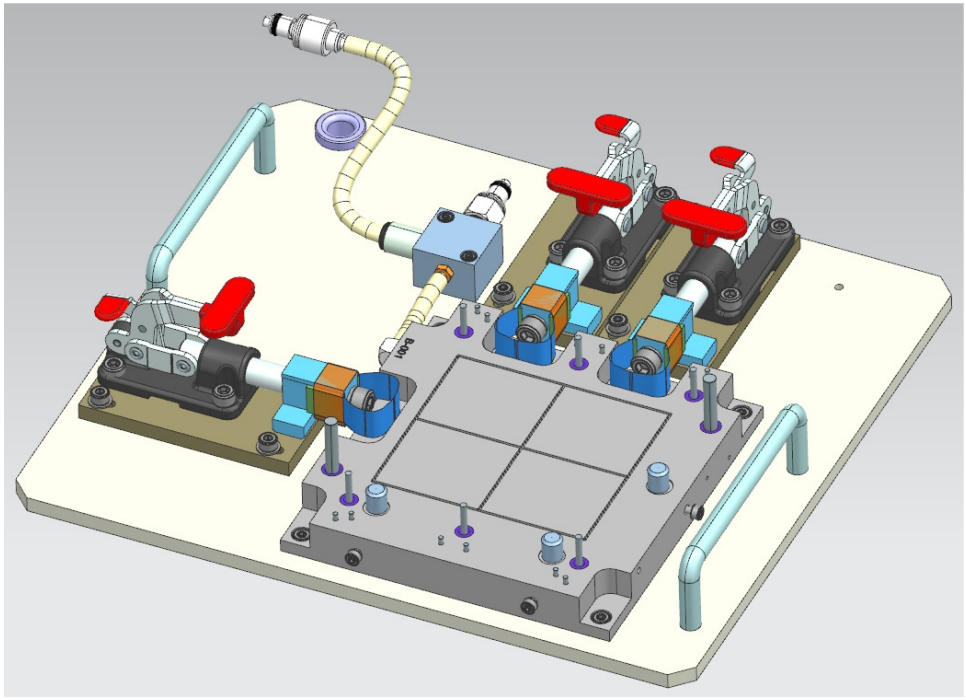
- A facemask / beard cover shall be worn whenever working near an exposed module
- Powder-free nitrile gloves shall be worn when handling module hardware

In addition, the AlCF material used to fabricate the module's main and stump bridges is **EXTREMELY FRAGILE!** The highest level of caution must be used when handling the module. Only authorized operators should be permitted to handle modules, and **NO UNPLANNED HANDLING** of a module should be allowed.

PROCESS STEPS

The 2S modules being built here come in two flavors: with 1 stump bridge or 2. The process for the two different types is basically the same except for the obvious difference in the number in stump bridges but also a less obvious change needed for the weight plate. The process here is described showing a two-stump configuration, but process differences between the two types will be highlighted where applicable.

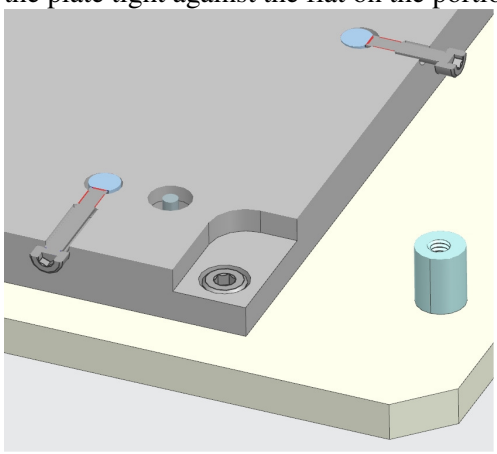
Also, it should be noted that at several points in this process, interaction with the Traveler system is necessary. Due to the variety of ways this is being managed, the specific details on performing these interactions is outside the scope of this document.

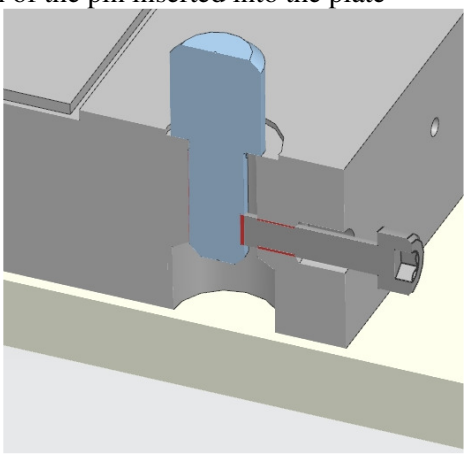
1. Preparation of the assembly fixture (F10139554)
   a. 
   b. For changes relevant to construction of the thicker 4.0mm module type, see the Appendix at the end of this procedure.

c. The fixture serial number being used should be associated with the module serial number to be assembled[3]. The module number is to be assigned by the Production Coordinator.

d. Remove the 2.5mm and 5.0mm locating pins

e. The sensor edge locating pins should be inserted with the setting screws on the sides of the plate tight against the flat on the portion of the pin inserted into the plate



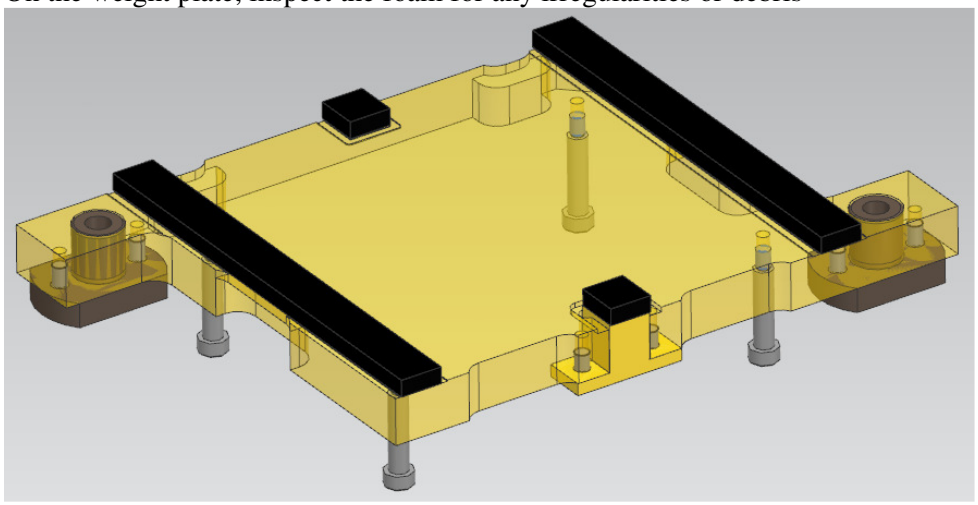


f. Withdraw the pushers into their retracted position

g. Clean the surface of the fixture with an alcohol wipe and allow to dry

h. Prepare the protective sensor sheets (Qty=2 of optical filter paper[4]) and locate one of them into place on the fixture

i. On the weight plate, inspect the foam for any irregularities or debris



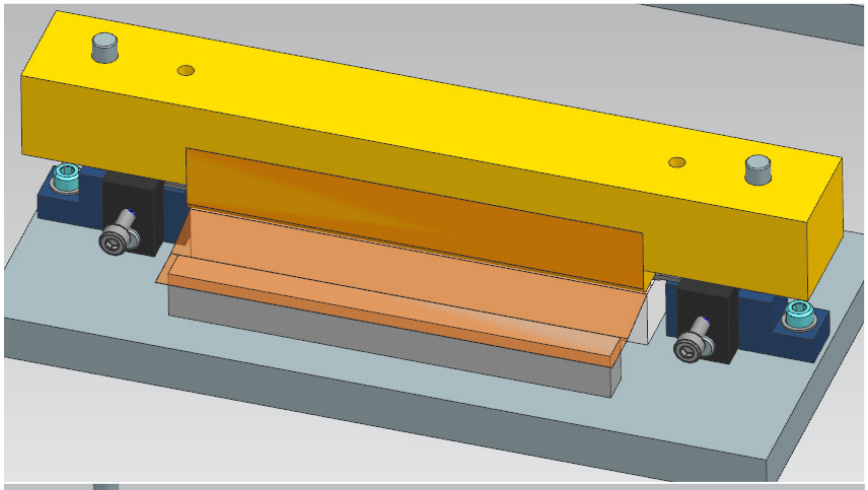
i. **TWO STUMP MODULES:** The image above shows the foam layout that is used for this module type, with an extra piece of foam placed over the second stump bridge.

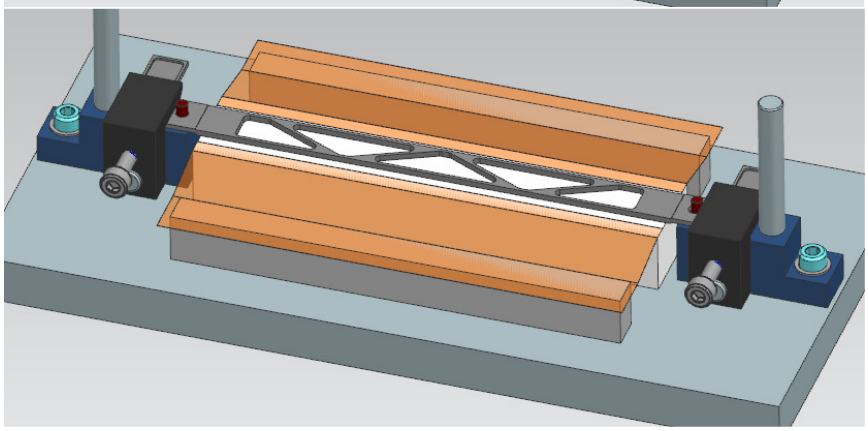
[3] At Fermilab, this is done with the electronic Traveler system. Other institutes will need to develop their own process to maintain serial number tracking information here.

[4] Optical paper cut to 99 x 90 mm size (just slightly smaller than the sensor footprint), sheet supplier = https://berkshire.com/shop/cleanroom-wipes/nonwoven/lensx-90/ln90040624p/ or equivalent

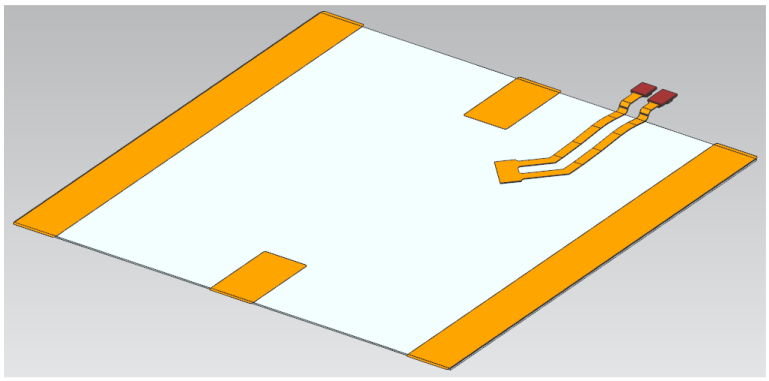
ii. **ONE-STUMP MODULES:** For modules without a second stump bridge, use of the additional piece of foam must be avoided to prevent application of weight pressure on the unsupported region of the top sensor. Therefore, the insert to which the second piece of foam is attached must be removed from the weight plate whenever a single-stump module is being constructed.

2. Preparation of the main bridge epoxy application fixture (F10136784)
    a. On the main bridge epoxy spreading tool, verify that the epoxy transfer bar is clean and that the Kapton tape edge guides are in suitable shape for epoxy spreading on the raised area of both the base and the bar
    b.





3. Acquisition of sensors:
    a. The prepared sensors to be used in the module are packed in Gelpak cases and shall be assigned by the Production Coordinator
    b. Sensors may be handled with an ESD-safe pump-driven vacuum pickup pen
    c. Visually inspect the TOP SENSOR for the following features:

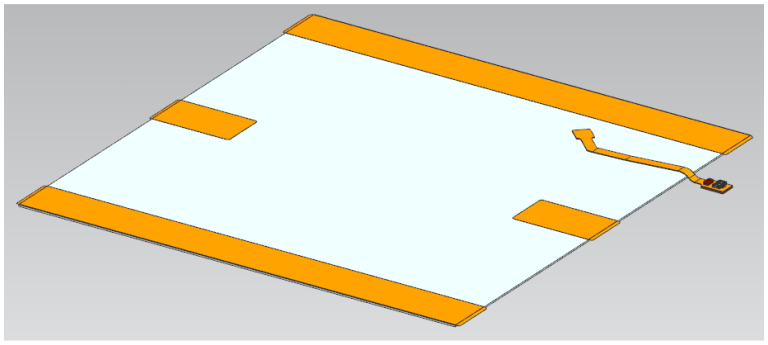
i. 

ii. Tab placement located as shown. An encapsulated wirebond connection to the back plane of the sensor should be visually checked to verify its integrity.

iii. Kapton isolators should be visually inspected to verify that there are minimal air bubbles and that the Kapton extends approximately 0.7mm from the edges of the sensor.

1. Air bubbles should cover less than ~10% of the Kapton surface area
2. Too short an edge overhang increases the risk of an electrical short
3. Too long an edge overhang could interfere with module mounting
4. Discrepancies here should be reported to the Production Coordinator before proceeding

d. Visually inspect the BOTTOM SENSOR for the following features

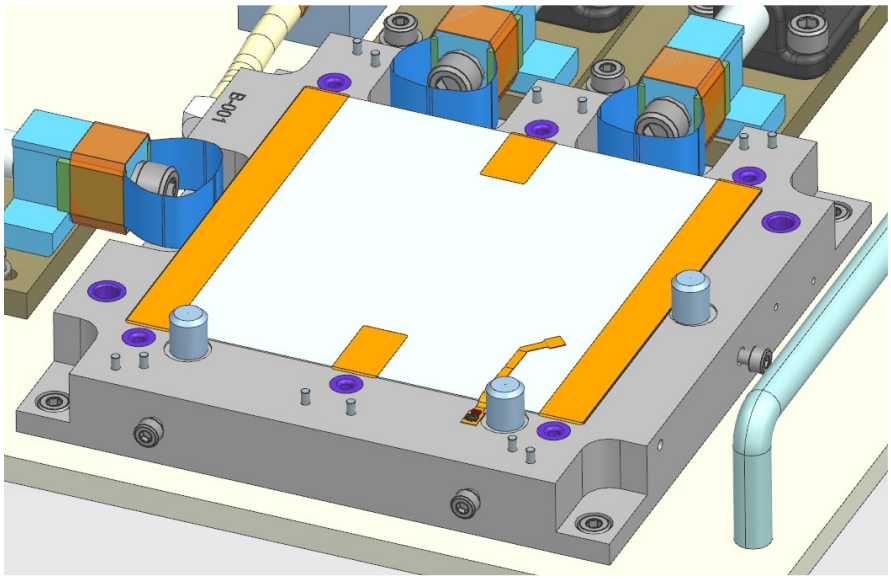
i. 

ii. Tab placement located as shown. An encapsulated wirebond connection to the back plane of the sensor should be visually checked to verify its integrity.

iii. Kapton isolators should be visually inspected to verify that there are minimal air bubbles and that the Kapton extends approximately 0.7mm from the edges of the sensor.

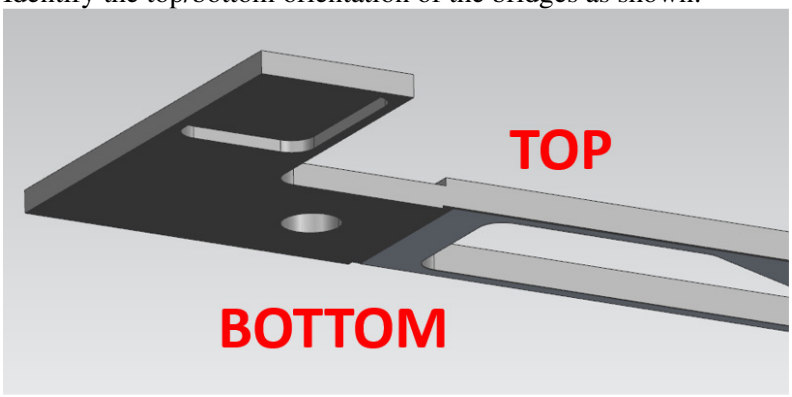
1. Air bubbles should cover less than ~10% of the Kapton surface area
2. Too short an edge overhang increases the risk of an electrical short
3. Too long an edge overhang could interfere with module mounting
4. Discrepancies here should be reported to the Production Coordinator before proceeding

e. Record the sensor numbers in the Traveler

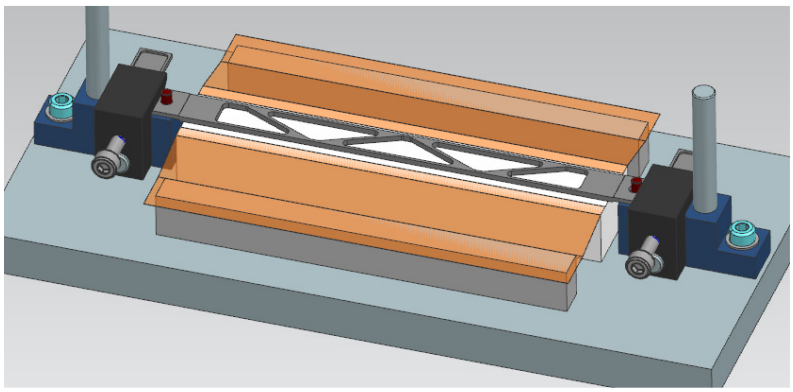
4. Acquisition of bridges
    a. Retrieve 2 main bridges from storage and visually inspect them for any flaws, broken webs, etc.
    b. The number of stump bridges to be installed on the module must be specified by the Production Coordinator. Retrieve 1 or 2 stump bridges, as required, from storage and visually inspect it/them for any flaws.
    c. Set aside any damaged bridges found for the Production Coordinator
    d. Record the bridge batch numbers in the Traveler
5. Mix a batch of Polytec TC-437 epoxy[5] per the manufacturer's instructions
    a. Note that the advertised pot life for this epoxy is 2 hours
6. Placement of the BOTTOM sensor:
    a. 
    b. Verify that the filter paper is in place on the fixture surface
    c. Verify that the spring pushers are retracted
    d. Use the Gelpak plate vacuum release tool to release the Gelpak plate's film from the surface of the sensor
    e. Use a vacuum pickup tool to remove the sensor from the Gelpak plate
    f. Place the sensor, active side down, on the fixture's protective filter paper sheet in the orientation shown. Push the sensor gently against the positioning edge pins to set its location, using either the vacuum pickup tool or the fixture spring pushers.
    g. Apply base plate vacuum
    h. Withdraw the spring pushers from the sensor edges and visually verify that the sensor is still in contact with all three edge pins

[5] https://www.polytec-pt.com/fileadmin/user_uploads_Polytec-PT/home/documents/Polytec_Klebstoffe_ENG/Polytec_TC_437_engl.pdf

7. Placement of the main bridges
    a. The steps & images below are centered on the bridges used in the fabrication of 1.8mm type modules. For differences pertaining to the 4.0mm type modules, see the Appendix at the end of this procedure.
    b. Identify the top/bottom orientation of the bridges as shown:



    c. Dispense epoxy on the raised area of the base plate and top bar and use a razor blade to squeegee the epoxy to a 0.075mm thickness using the Kapton tape edge strips as guides. Clean up any excess epoxy from the ends of the raised area.
    d. Position the bridge into place pocketed-bottom-side-up on its loose-fitting alignment pins. Install the magnetic keeper tabs over its ends as shown below, guiding them into place so the overhanging portion doesn't scratch the bridge.
    e.



    f. Install the top bar in place on the guide pins and press against the bridge
    g. Withdraw the top bar. The tabs at the ends of the bridge will keep it from sticking to the bar.
    h. Inspect the bridge for full epoxy coverage, touching up as necessary
    i. Remove the bridge from the bottom plate and transfer it into place, pocketed bottom-side down, on the bottom sensor in the orientation shown below. The bridges should now be oriented top-side up, as shown in the image below.

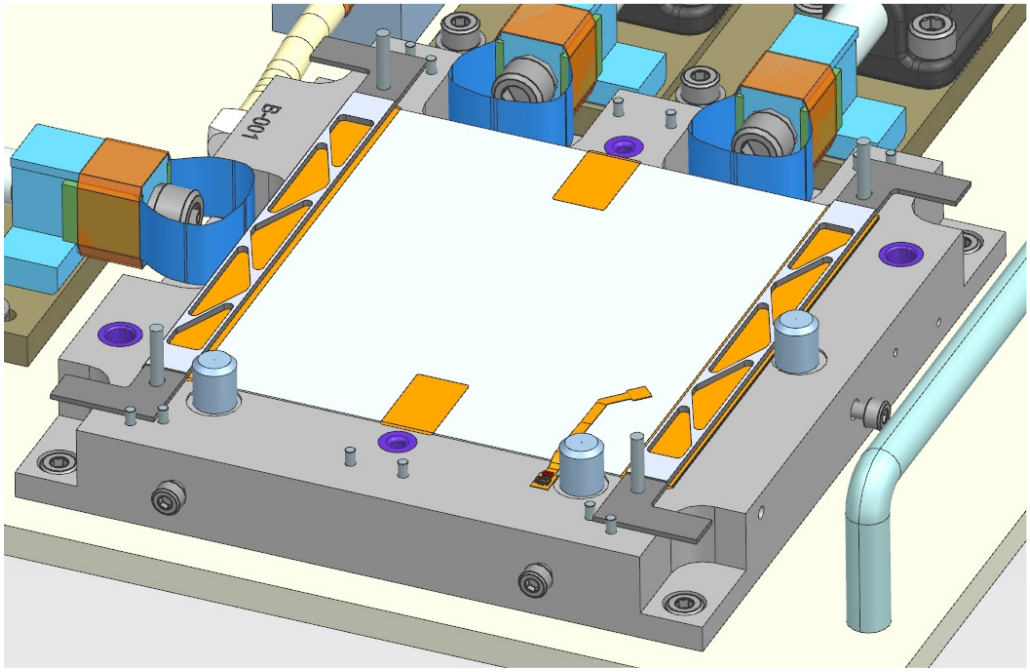
j. Carefully insert the Ø2.5mm alignment pins[6] through the main bridge holes/slots and into the holes in the base plate. Alternatively, the bridges may be slipped down over already-installed Ø2.5mm pins.

k. Release the base plate vacuum and reapply the spring pushers. This is needed in case the action of inserting the pins into the bridges causes the grip of the epoxy to drag the sensors slightly away from the edge pins.

l. Visually re-inspect the fit between the sensor edge and the edge pin

m. Re-apply the base plate vacuum and then withdraw the pushers

n. Press gently on the bridges with a Q-tip to seat the bridges against the bottom sensor

o. 

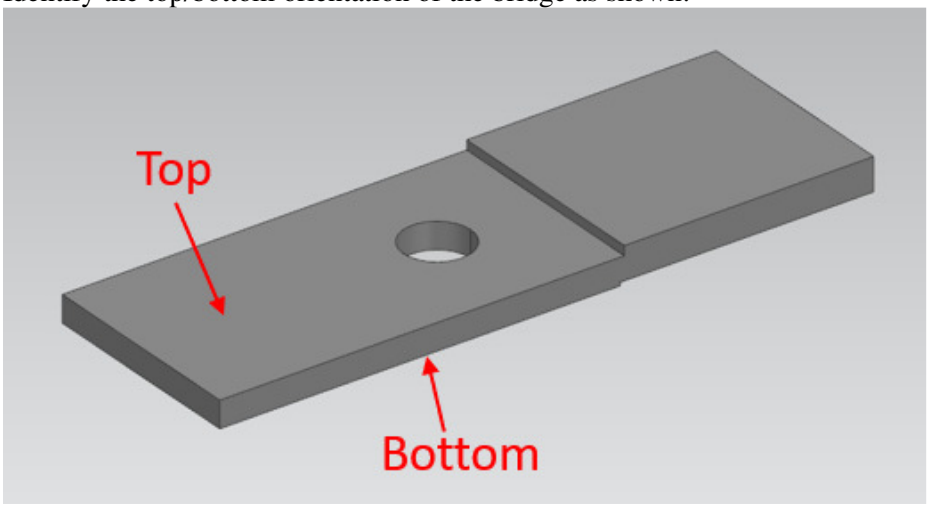
p. Double-check that the holes and slots in the main bridges are configured as shown above. If reversed, it means that bridge has been placed upside-down and this must be corrected.

q. Visually inspect the epoxy previously-applied to the exposed top surface of the bridge and touch up the epoxy coverage as needed

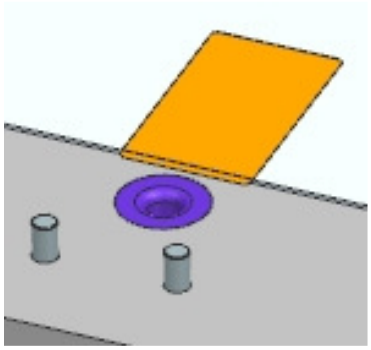
r. Re-spread the epoxy on the epoxy application jig and repeat this process for the 2nd main bridge

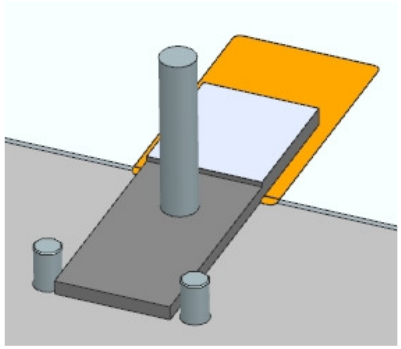
[6] These precision 2.500mm-diameter guide pins come 2 inches long and can be cut to a shorter length as needed by the end user (https://www.mcmaster.com/2281A2/).

8. Placement of the stump bridge(s)
    a. Identify the top/bottom orientation of the bridge as shown:

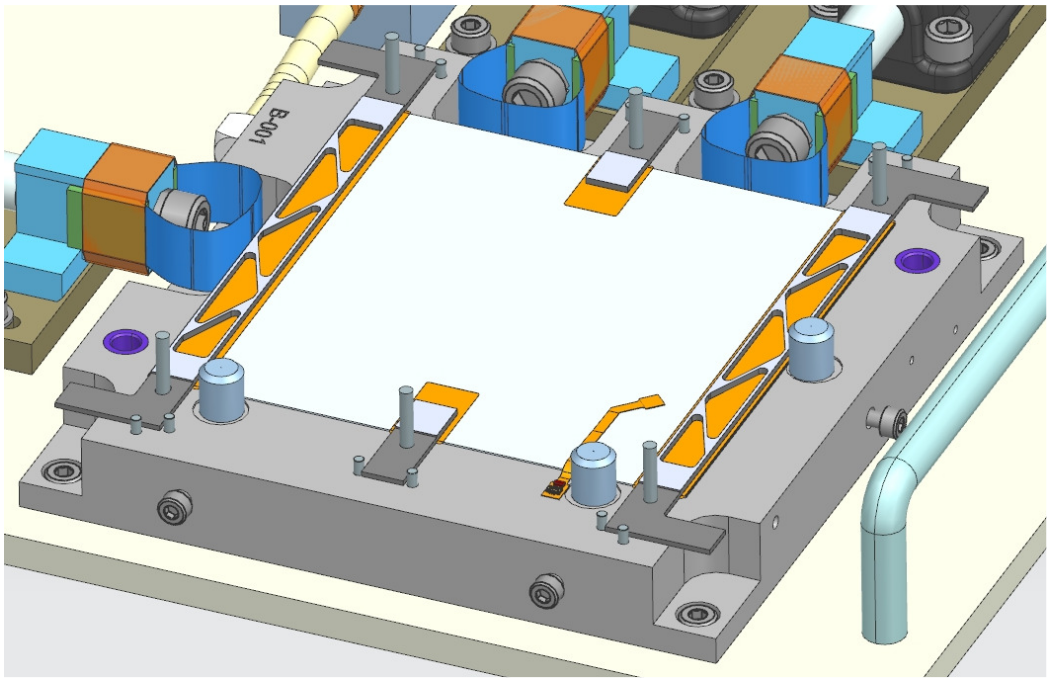


    b. Spread the epoxy film again on the bridge epoxy jig
    c. Place the stump bridge BOTTOM SIDE UP on the jig, as was done for the main bridges. Two bridges can be done at the same time if that is the style of module being assembled.
    d. Install the magnetic keep tab, as was done for the main bridges. Hole the stump bridge straight if needed.
    e. Install the top bar in place on the guide pins and press against the stump bridge(s)
    f. Withdraw the top bar. The tabs at the ends of the bridge will keep it from sticking to the bar.
    g. Inspect the bridge for full epoxy coverage, touching up as necessary
    h. Remove the bridge from the bottom plate and transfer it into place, bottom-side down, on the bottom sensor in the orientation shown below. Insert the Ø2.5mm pin through the bridge first and then install in place. The bridges should now be oriented top-side up, as shown in the image below. The raised portion that will contact the upper sensor protrudes UPWARDS. Note that the length of bridge protruding from the sensor will not contact the surface of the fixture plate but will be approximately 0.4mm above it.
    i. Press gently on the bridge with a Q-tip to seat the bridges against the bottom sensor
    j.

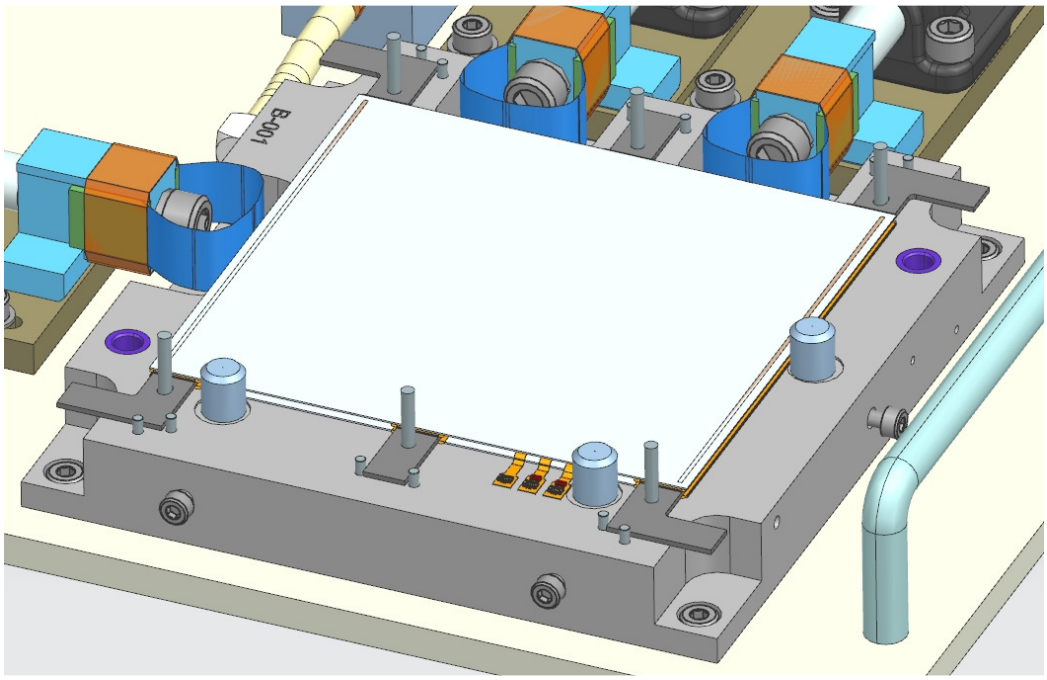




    k. Verify that the epoxy is in place on the top surface of the stump bridge that will contact the top sensor. Touch up if necessary.

l. 

9. Placement of the TOP sensor:

a. 

b. Recheck the epoxy application on the main bridges and touch up as necessary

c. Recheck the epoxy application on the stump bridge(s) and touch up as necessary

d. Using the sensor pickup tool, remove the sensor from its Gelpak case

e. Carefully place the top sensor artwork-side up in the orientation shown (all bias tabs near each other) against the three edge pins and then lightly against the bridge spacers

f. Release the base plate vacuum (to be reconnected below)

g. Slowly engage the pushers that presses towards the edge with two edge pins, activating both of them at the same time

h. Slowly engage the pusher that presses towards the edge with a single edge pin

i. Visually verify that the sensor is positioned against all three edge pins

j. Re-apply the base plate vacuum

10. Place the second filter paper sheet[7] on the top face of the sensor (same size as the one underneath the bottom sensor). It should fully cover the sensor surface in the areas where the weight plate foam strips will press on the module.

11. Install weight plate

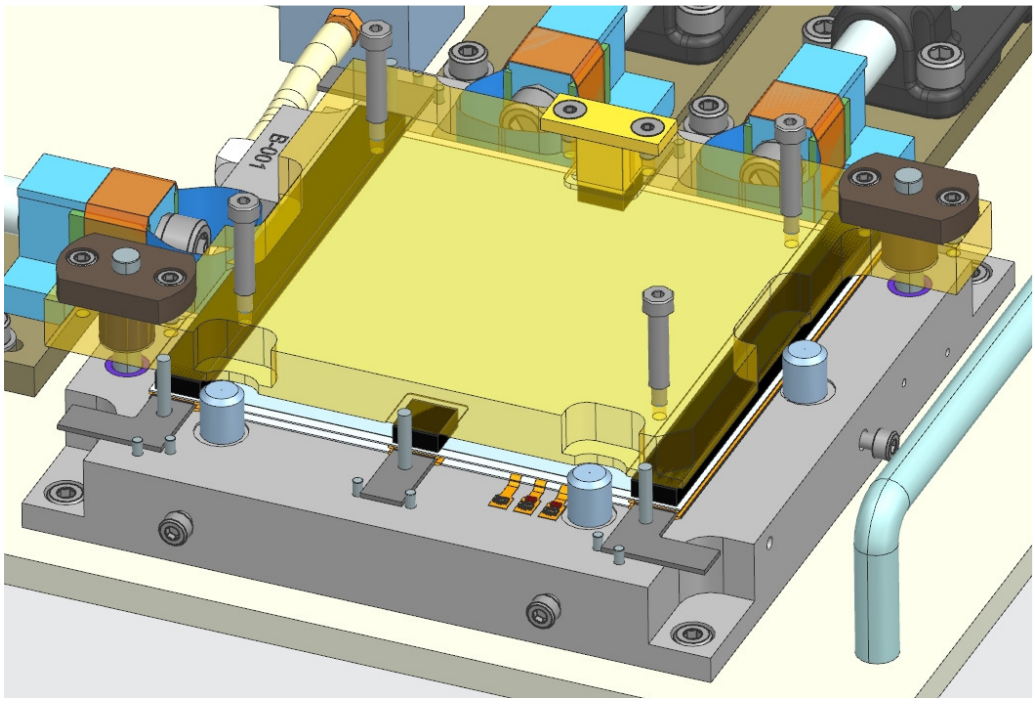
    a. Install the two 5mm pins into their base plate holes

    b. Check that the weight plate foam configuration matches the number of stump bridges being installed

        i. ONE STUMP BRIDGE = without insert that has 2nd stump foam piece

        ii. TWO STUMP BRIDGES = with insert that has 2nd stump foam piece

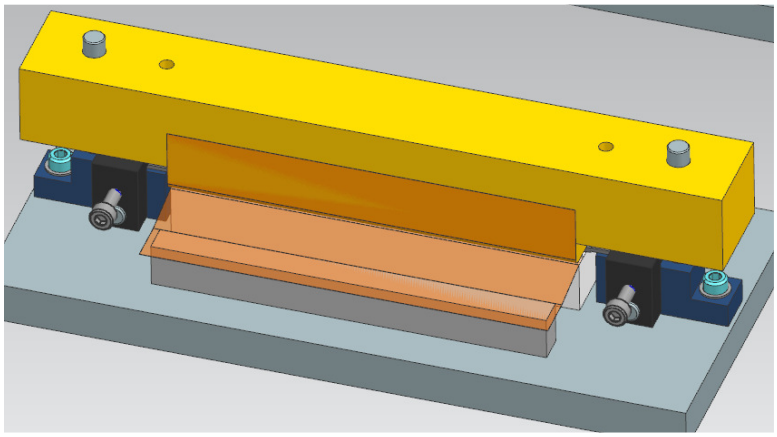
    c. Carefully lower the weight plate into place, with the clearance cutouts oriented to match the pusher and edge pin layout as shown below

    d. 

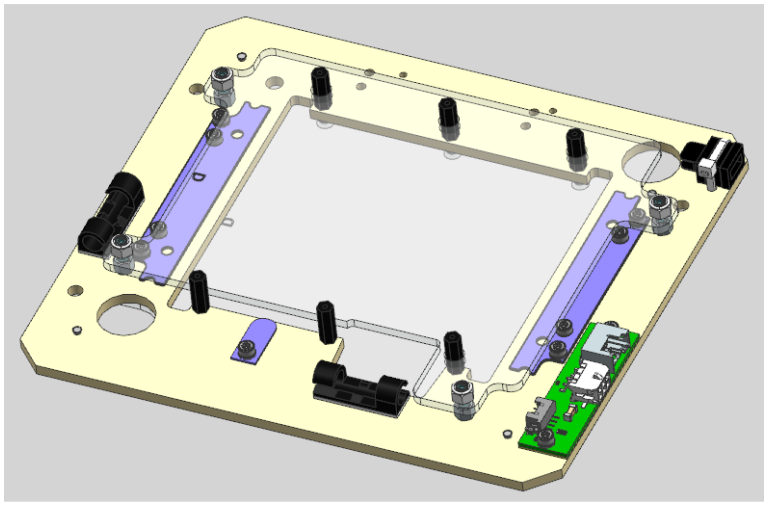
12. Visually verify that the sensors remain positioned against the edge pins

[7] Optical paper size and supply specified in Step 1 above.

13. If needed to clear the workspace area for construction of additional modules, gently transfer the fixture into a storage rack while the epoxy cures[8]
14. Complete any remaining record-keeping requirements in the Traveler
15. Once use of the bridge epoxy application jig is complete, thoroughly clean leftover epoxy from all surfaces as necessary. Remove end blocks with pins to aid cleaning and replace Kapton as needed.

a. 

16. Wait for at least 24 hours for the epoxy to cure
17. After the epoxy has cured, the module is to be transferred into a carrier plate where it will then proceed to the gantry system for alignment inspection
    a. Acquire the carrier plate to be used. Use the Traveler system to associate the module serial number with the carrier serial number for part tracking[9]. The procedure for loading modules into a carrier plate is defined in Fermilab document ED0014642[10].

b. 

[8] To help maintain vacuum tubing organization, the fixture is equipped with two vacuum quick disconnects, each with an internal check valve, in order to allow swapping of the vacuum supply to some dedicated tubing local to the storage rack.
[9] The details of this process will be specific to the various assembly institutes.
[10] Copy available in EDMS at https://edms.cern.ch/document/2746436

c. Prepare the carrier plate assembly to receive the new module as described in the carrier plate procedure.

d. Retrieve the fixture from the storage rack (if applicable)

   i. Attach the workbench vacuum line to the fixture's vacuum block connection

   ii. Disconnect the vacuum line from the curing rack vacuum feedthrough

   iii. Gently remove the fixture from the box and transfer it to the work area

e. Carefully remove the weight plate from the surface of the top sensor. Do not let withdrawal of the plate pull the 5mm pins out of the fixture's support plate (extra M2 threaded holes are added into the support plate to allow use of set screws if needed).

f. Remove the weight plate's 5mm guide pins from the support plate

g. Retract all the spring plungers

h. Remove the three sensor edge pins

   i. Release the set screws in the sides of the plate

   ii. Slide the pins away from the sensor edges and carefully withdraw them from the fixture

i. Remove the filter paper from the top sensor

j. Visually inspect the module and the top sensor edges for any irregularities. Note any excess epoxy squeeze-out that extends past the Kapton tape edge, record on the Traveler for evaluation by the Production Coordinator.

k. Using tweezers on the bridge ends to prevent lifting, carefully withdraw the alignment pins from the 5 mounting holes/slots. Note that the bridge ends are suspended approximately 0.4mm above the fixture plate, so while the bridges are not to flex upwards when withdrawing the pins they are also not to be pressed downwards while restraining them.

l. Turn off the base plate vacuum

m. Carefully transfer the module to the carrier with the BV/G tabs installed in the region with the cutout where the Service Hybrid wrap-around will eventually go

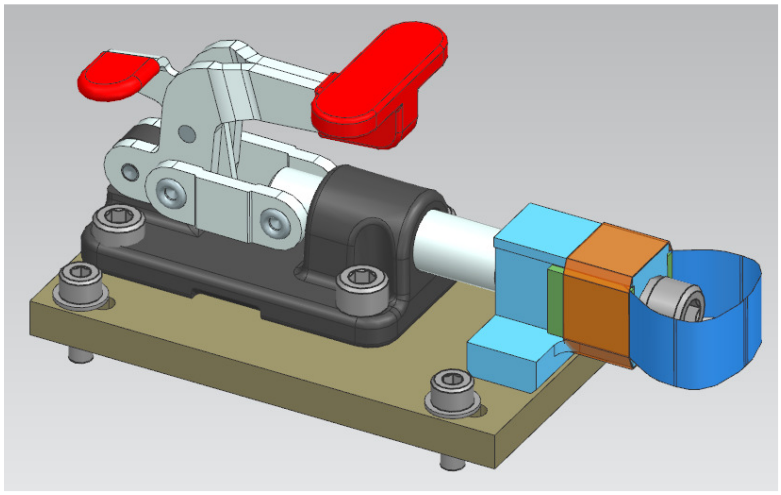
n. Install bridge fasteners, covers, etc. as described in the carrier plate procedure

o. Visually inspect the module and the bottom sensor edges for any irregularities. Note any excess epoxy squeeze-out that extends past the Kapton tape edge, record on the Traveler for evaluation by the Production Coordinator.

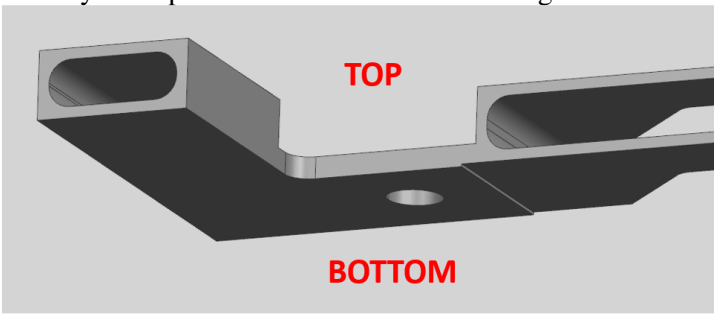
18. Complete any remaining record-keeping requirements in the Traveler

APPENDIX
4mm Modules

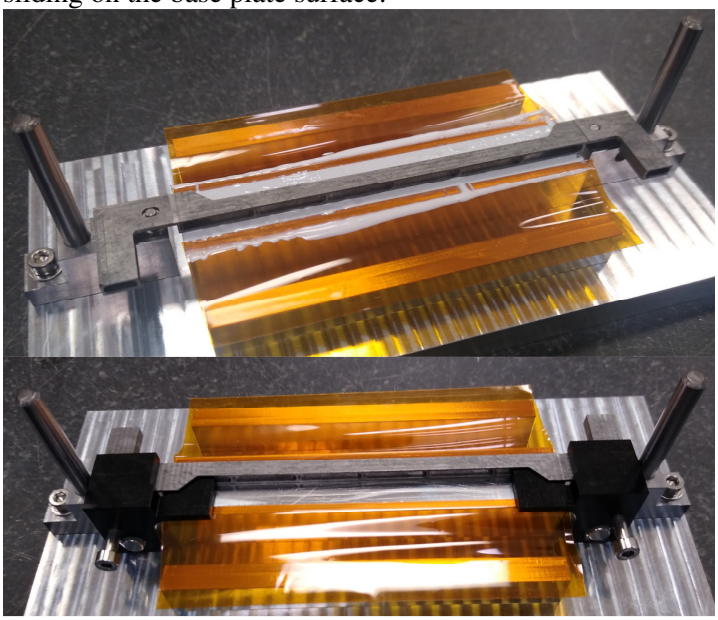
The same assembly process described above is used to assemble the thicker 4mm modules, but the following changes are necessary when working with this style module.

1. In order to keep the pusher spring centered on the silicon sandwich, a thicker pusher base plate is used to achieve the offset elevation. The individual pusher assembles must therefore be disassembled and reassembled with the appropriate base plate whenever changing module flavors. The base plates are color-coded for ease of identification as follows:
    a. 1.8mm Modules = raw aluminum color
    b. 4.0mm Modules = black anodization
    c. 

2. Epoxy Deposition on Bridge
    a. Main bridges for the 4mm modules
        i. Identify the top/bottom orientation of the bridge as shown:

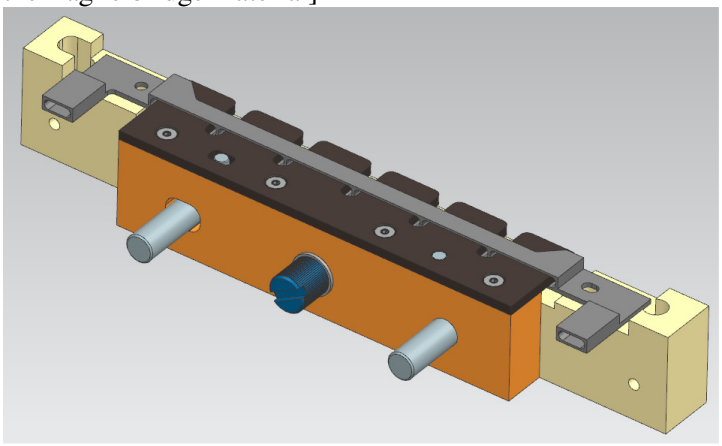


        ii. Dispense epoxy on the raised area of the base plate and top bar and use a razor blade to squeegee the epoxy to a 0.075mm thickness using the Kapton edge strips as guides. It is easier to do this with the mounting blocks with pins removed from the base plate. Clean up any excess epoxy and then install the mount blocks with pins into place.
        iii. Position the bridge into place bottom-side-up using the small pins in the mount blocks in the bridge alignment hole & slot. Install the magnetic keeper tabs over its ends as shown below, guiding them into place with the bottom face of the tab sliding on the base plate surface.



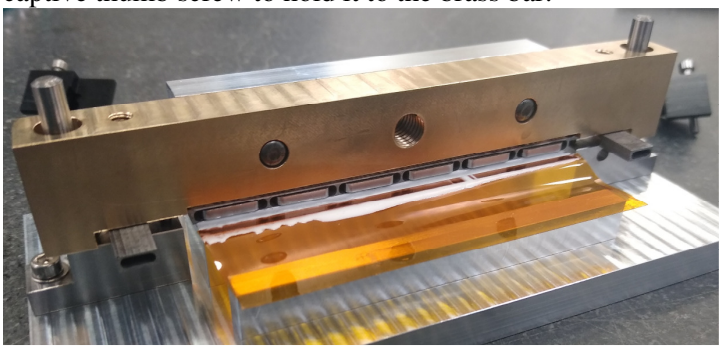
        iv. Install the top bar in place on the guide pins and press against the bridge
        v. Withdraw the top bar. The tabs at the end of the bridge will keep it from sticking to the bar.
        vi. Visually inspect the bridge's "bottom side" (which is now facing upwards) for full epoxy coverage, touching up as necessary
        vii. A lifting bar assembly can be used to lift the bridge from the fixture base [in case the suction force holding the bridge is too great to lift the ends without damaging

the fragile bridge material]



viii. Remove or at least withdraw the comb plate subassembly from the brass pickup bar.

ix. Install the brass pickup bar – the protruding side pins can stick out in either direction (users may develop their own preference). Slide the comb plate assembly into place so its teeth engage with the bridge cutouts and then fasten its captive thumb screw to hold it to the brass bar.



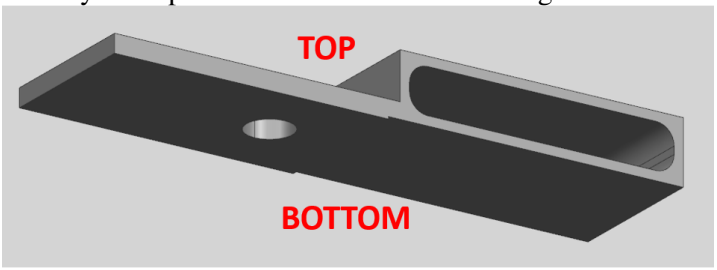
x. Lift the bar upwards to separate the bridge from the base plate and flip it over, rotating it in the direction of the comb teeth so the bridge stays in place on the comb.

xi. Visually inspect the bridge's "top side" (which is now facing upwards) for full epoxy coverage, touching up as necessary. Alternatively, this step can be done once the bridge has already been installed onto the bottom sensor.

xii. Install the main bridge "top-side" upwards on the sensor gluing fixture as described in the main body of this procedure.

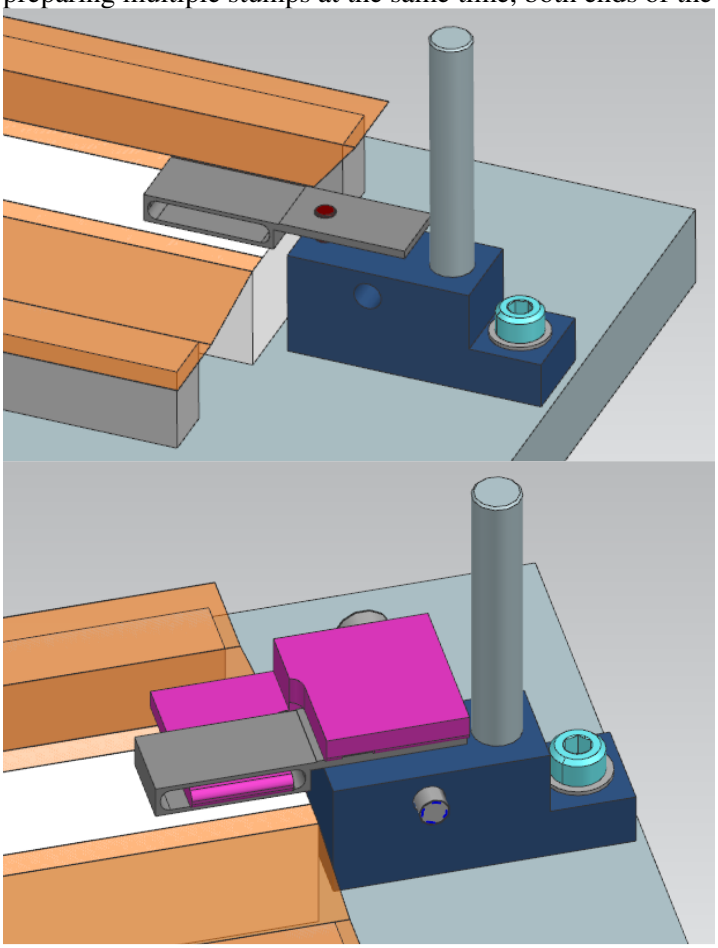
b. Stump bridges for the 4mm modules

i. Identify the top/bottom orientation of the bridge as shown:



ii. Dispense epoxy on the on base plate raised area on top bar as described above

iii. Position the stump bridge into place bottom-side up on its loose-fitting alignment pin. Install the magnetic keeper tab over its end as shown below. When preparing multiple stumps at the same time, both ends of the fixture are used.



iv. Install the top bar in place on the guide pins and press against the bridge

v. Withdraw the top bar. The tab at the end of the bridge will keep it from sticking to the bar.

vi. Visually inspect the bridge's "bottom side" (which is now facing upwards) for full epoxy coverage, touching up as necessary

vii. Remove the magnetic holding tab. Then remove the stump from the base and transfer it to the sensor alignment fixture, positioned into place on the bottom sensor as described in the main body of this procedure.

3. When installed in place on the sensor gluing fixture, the bridges are oriented as shown