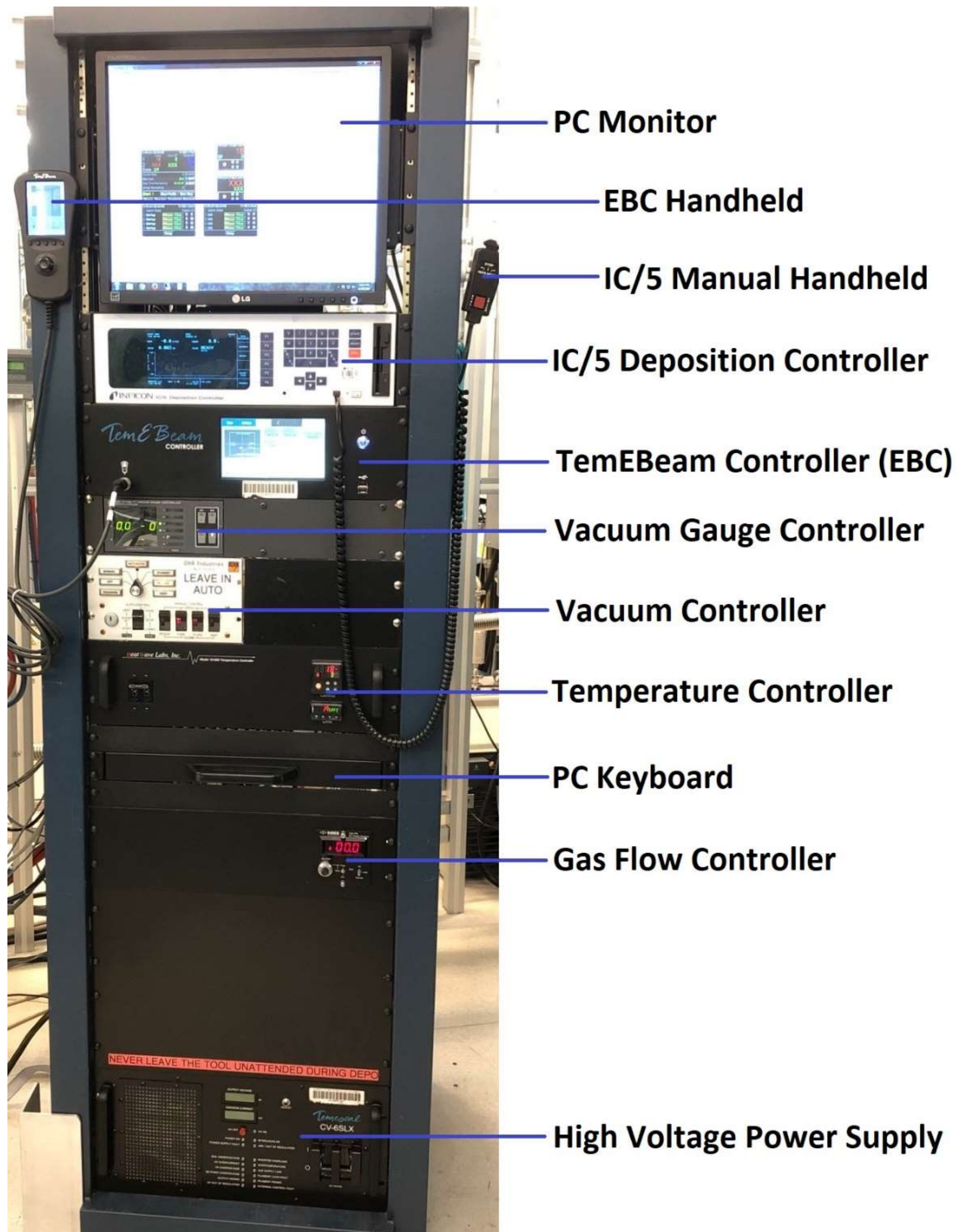
E-Beam #2 Operation

Overview
This procedure covers the operation of E-Beam #2. Some sections apply to optional operational steps; these are color keyed as follows:

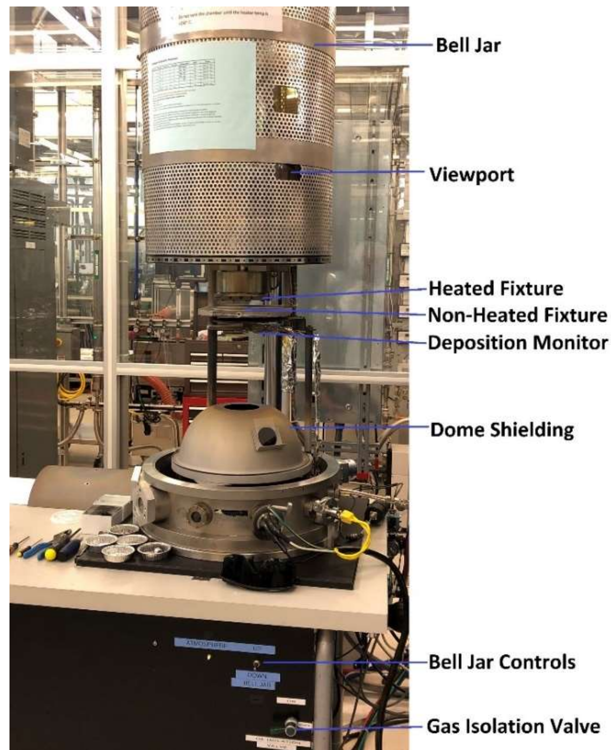
- Black= Standard Operation
- Orange= Heated Sample Holder Operation
- Green= Oxygen Gas Flow Operation

There is also a visual aid at the tool that provides information on the generic process and material settings.

SYSTEM COMPONENTS



E-Beam #2 Operation



Restrictions & Precautions

- Always ensure that a glass slide is installed on the dome shielding before closing the chamber.
- Keep hands and foreign objects clear of the chamber sealing surface when lowering the bell jar.
- Never modify the material settings for the generic processes, refer to the visual aid at the system for more info.
- Never leave the system unattended during deposition.
- Always use the tinted safety glasses when looking at the beam. These can be found at the deposition systems in the same bay.
- The TOX wafer must always be in place when using the heated sample holder.
- Never use copper sample clips on the heated sample holder, only Inconel clips. If you are not sure about the clip type, contact Staff.
- All 8 sample clips must be in place when using the heated sample holder.
- Never tighten the heated sample holder clips screws using an Allen wrench/driver. Always use the torque driver at the system as these screws are easily stripped.
- The heat shield must always be in place when using the heated sample holder.
- For heated runs, DO NOT vented the chamber until the temperature is <250°C.
- DO NOT handle the heated sample holder with your hands when unloading it after a heated run. Use the pliers at the system to unload it. Also do not place it on the work surface at the tool, set it on the non-heated sample holder.
- Always wait for the 5-minute idle ramp to finished before turning off the high voltage power supply (HVPS).
- For non-heated runs, always wait at least 10 minutes after turning off the HVPS to vent the chamber. This allows the E-gun filament time to cool down and minimizes the potential for it to oxidize.

E-Beam #2 Operation

Chamber Prep and Sample Loading

1. If the ion gauge is off, turn it on by pressing the IG1 button on the VACUUM GAUGE CONTROLLER. The green LED on the button will turn on and a pressure reading will be displayed next to IG on the controller display.

2. Look under the chamber at the ion gauge to see if the filament inside is flickering:

    - If it is STOP and contact Staff.
    - If it is not, you can proceed with using the tool. <u>Turn off the ion gauge by pressing the IG button before proceeding.</u>

3. On the CHA Industries AUTO-TECH II vacuum controller, move the AUTO-CONTROL switch up to the VENT position. The HI-VAC light will turn off and the VENT light will turn on.

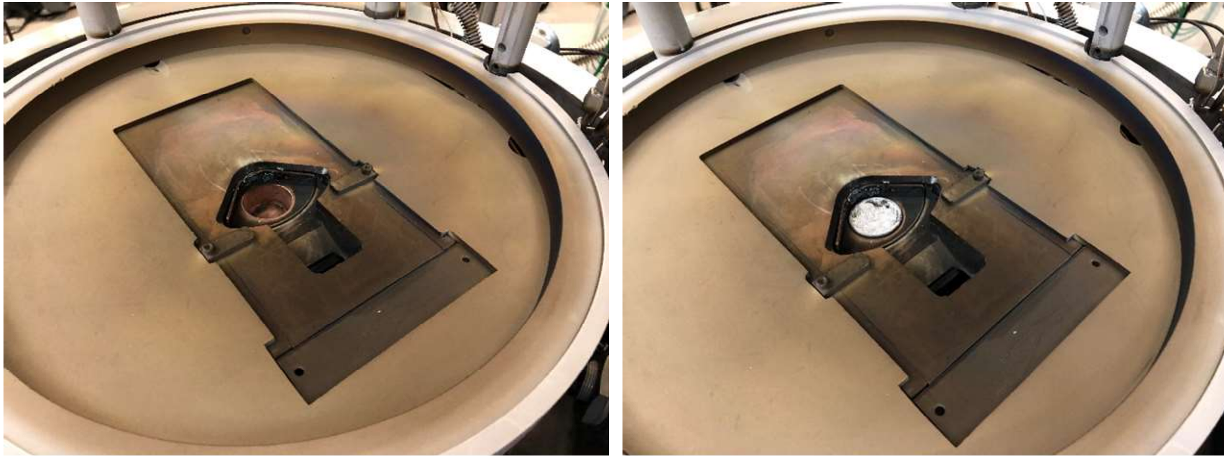
4. The reading on Channel A of the VACUUM GAUGE CONTROLLER should begin to go up and stop somewhere above/around 760 (mT). In conjunction with this 760 reading, the ATMOSPHERE LED (located on the front of the system) should turn on. **IN THE RARE INSTANCE THAT THE ATMOSPHERE LED TURNS ON BEFORE THE READING GETS TO AROUND 760, DO NOT RAISE THE BELL JAR UNTIL THE READING IS ABOVE/AROUND 760! YOU MUST ALSO INFORM STAFF THAT THIS HAS OCCURRED.** Raise the bell jar by holding the BELL JAR toggle switch in the UP position. Release the switch once the bell jar reaches its stop point.

5. On the vacuum controller, move the AUTO-CONTROL switch down to the middle STAND BY position to stop the flow of vent gas.
6. Begin to configure the chamber for your run:
   - There may be dome shielding installed in the tool. If present, remove the glass slide from the dome shielding. Then carefully remove the dome shielding, making sure to remove the O2 gas line from the left side of the dome while pulling the dome out.

NOTE: Before performing the following steps, you may want to use a vacuum cleaner to clean up any flaking. Additionally, there is a wire brush at the system that can be used to remove deposition build-up from the turret pocket(s).

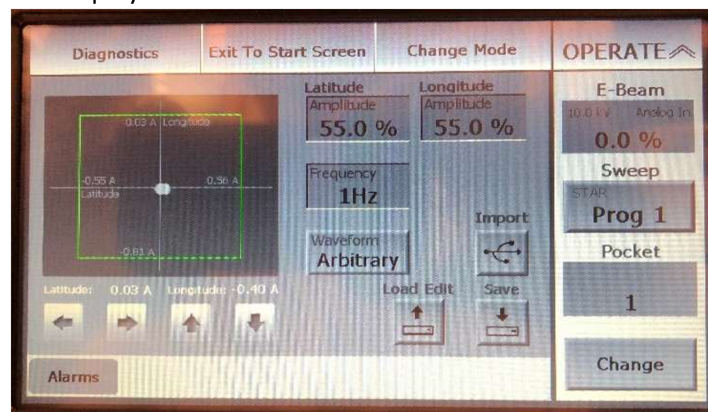
E-Beam #2 Operation

- Place the required source(s) in the turret pocket(s). If only running one source material, use turret pocket 1.

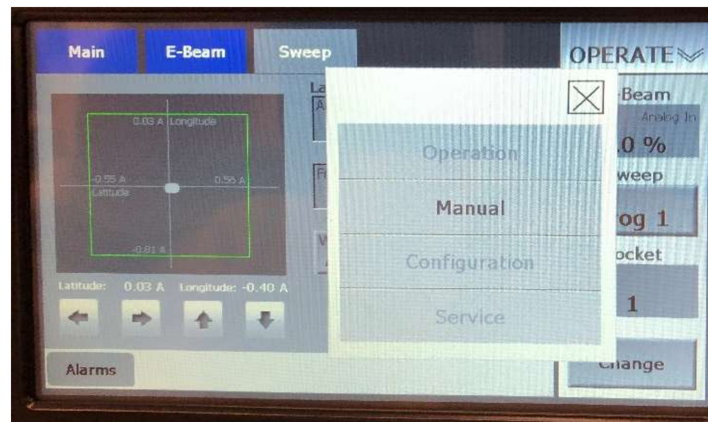


The pocket that is currently selected is displayed on the right side of the TemEBeam Controller (EBC) touchscreen. If you need to change the pocket, perform the following:

i. Touch OPERATE in the upper right corner, a menu will appear along the top of the display.



ii. Select Change Mode from this menu and then select Manual from the pop-up screen.



iii. Touch Change in the lower right corner, the fields above will change from grey to white.

iv. Touch the Pocket field and a pop-up screen will appear. Enter the pocket #, 1 - 4, that you need, press Enter and wait for the turret to locate the selected pocket.

v. If needed, repeat the above steps for additional sources.
IMPORTANT: Make sure to keep track of what materials are in what pockets.

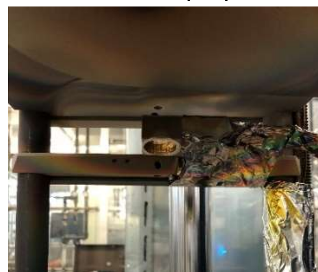
vi. Touch MANUAL in the upper right corner, a menu will appear along the top of the display.

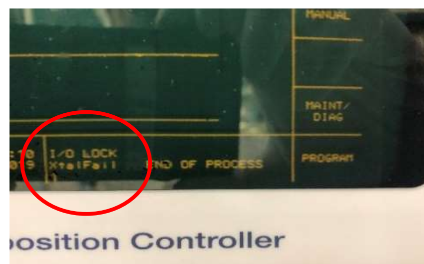
vii. Select Change Mode and then select Operation from the pop-up screen.

- Verify the crystal life by selecting SENSORS (F2) on the Inficon IC/5 Deposition Controller (IC5). Change the crystal if the XTAL LIFE is >100 for sensor #1 (all other sensors should be ignored).

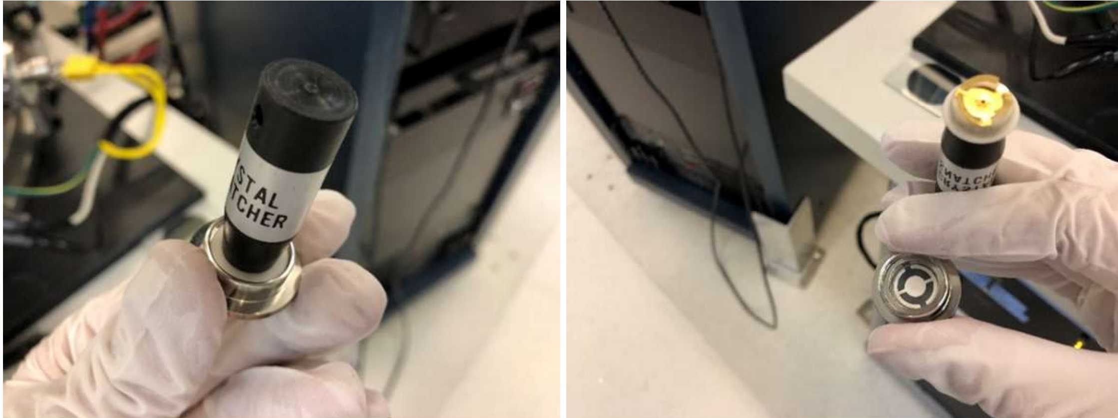
Change the crystal as follows:

i. Remove the crystal sensor head from the deposition monitor by pulling it off. The IC5 will display XTALFAIL 1 at the bottom of the screen.



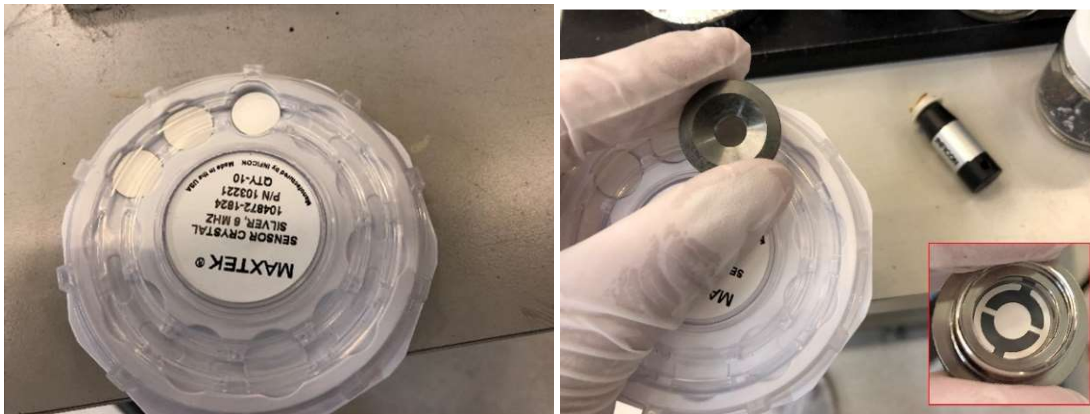


ii. Insert the Crystal Snatcher into the crystal sensor head ceramic retainer using a small amount of pressure to wedge the snatcher into the retainer, then pull the ceramic retainer straight out.



iii. Remove the crystal by turning the sensor head over. If it does not fall out, use the tip of some tweezers to push it out. Discard it in the small foil dish of used crystals.

iv. Get the pack of crystals at the system and rotate the case opening to the next crystal. Place the crystal sensor head directly over the new crystal and flip them over together. The new crystal should fall into place in the sensor head with the electrode side facing you. If for some reason it does not, use clean tweezers to manipulate it into place.



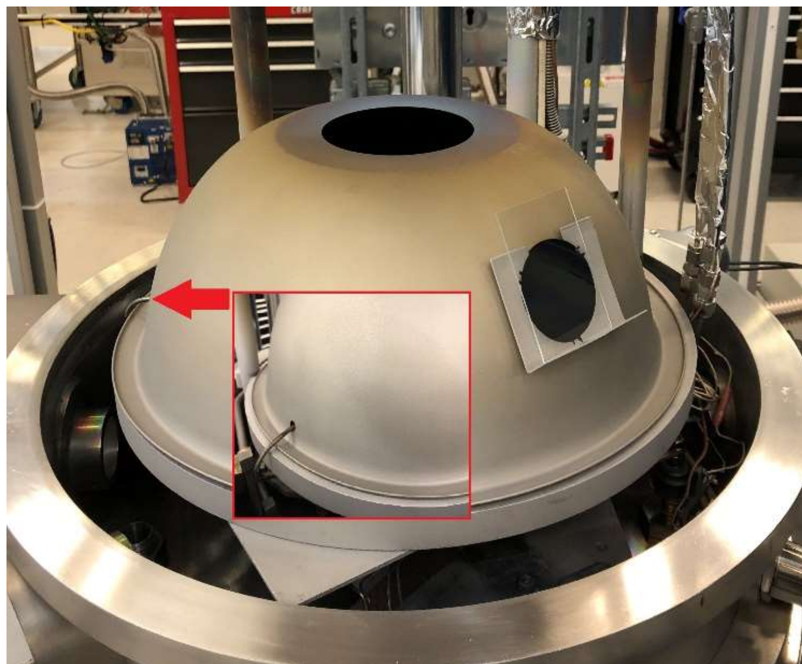
v. Using the Crystal Snatcher, re-install the ceramic retainer into the sensor head. Once it is properly seated, use a slight side-to-side motion to release the Crystal Snatcher. Now, using the bottom of the Crystal Snatcher, press on the ceramic retainer to ensure it is seated properly.

vi. Reinstall the crystal sensor head into the deposition monitor. After about 10 seconds the XTALFAIL 1 message on the IC5 will clear. Press OPERATE (F6) to return to the IC5 main screen.

TIP: Depositing various dielectric materials layers on a crystal can have negative effects on the accuracy of the crystal. Due to this, all of the generic processes developed for the system and calculation of the tooling factors were performed using a new crystal for initial and subsequent verification runs.

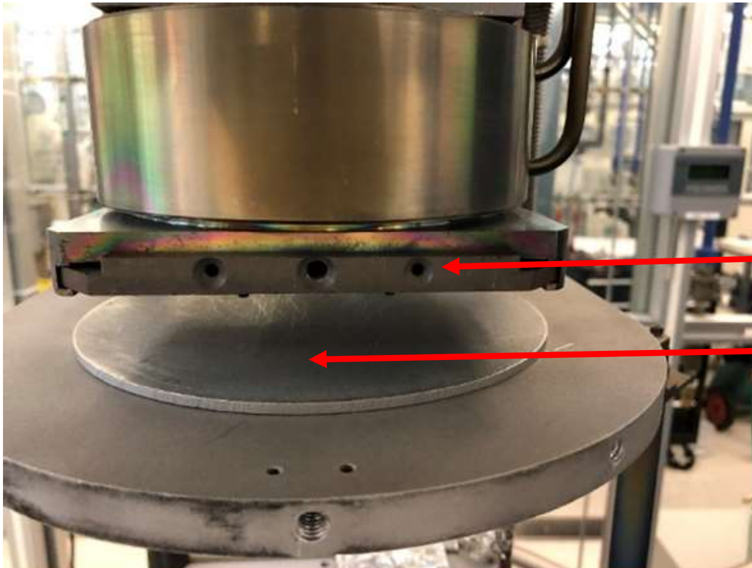
- Retrieve the correct dome shielding for your process by looking at the engraved labeling above the glass slide holder. There are three dome shields; SiO_2, ITO & Misc., located on the right side of the electronics rack. The SiO2 and ITO domes are for single layer films only. If you are running SiO_2 with another material, then you must use the Misc. dome.

- Carefully re-install the dome tooling, making sure to insert the O2 gas line into its hole.

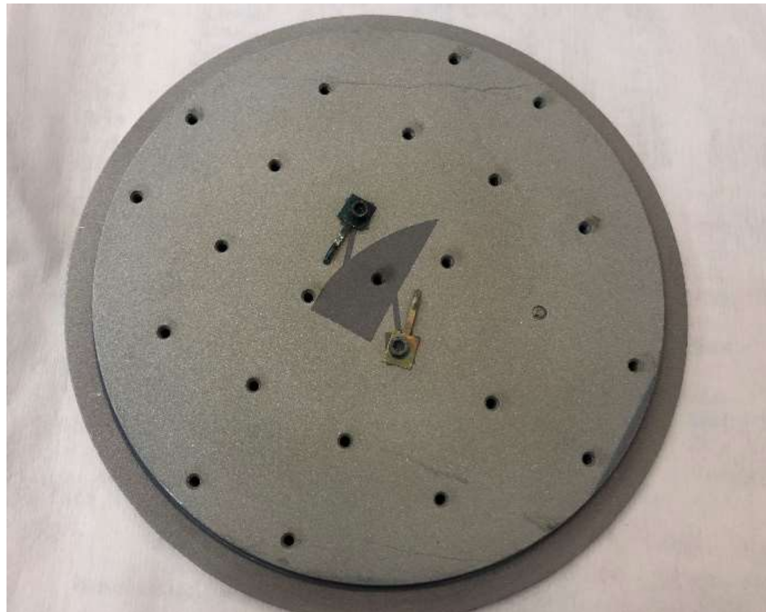


- Place a 75 x 50 mm glass slide, standing on its shorter edge, on the front of the dome tooling (these are the larger glass slides in the lab). **THIS IS VERY IMPORTANT AS FAILURE TO DO SO WILL RESULT IN COATING OF THE BELL JAR, MAKING VEIWING THE BEAM POSITION EXTREMELY DIFFICULT AND IT WILL REQUIRE STAFF MAINTENANCE TO FIX!**

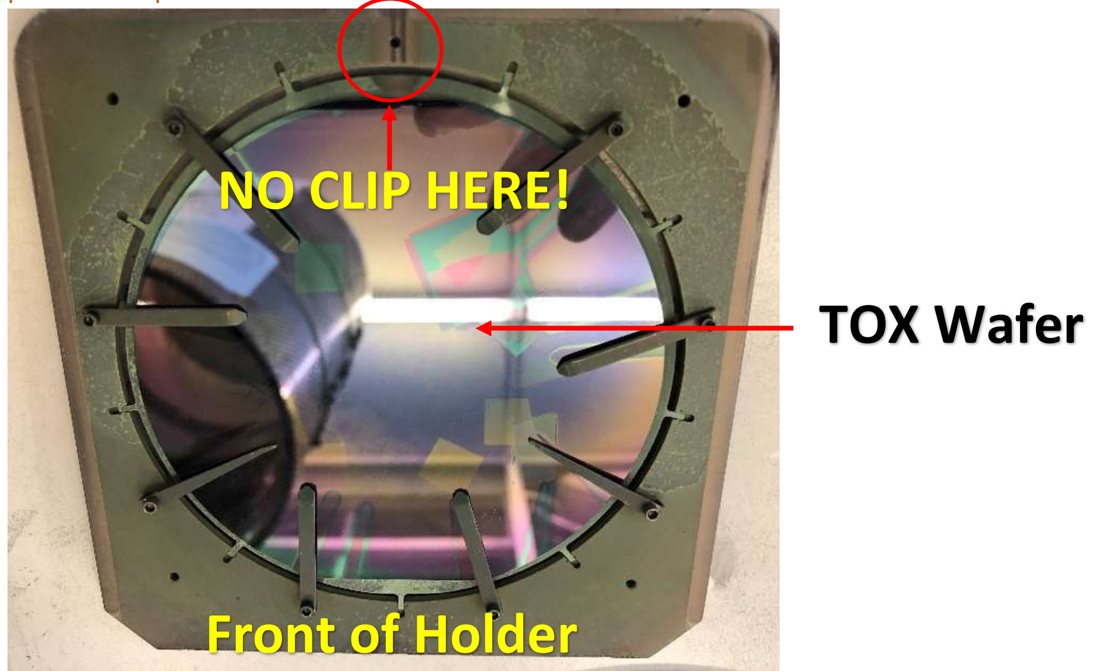
7. Remove the sample holder you require, non-heated or heated, from its holding fixture. If you are using the heated sample holder, you must also remove the non-heated sample holder and leave it out during your run.



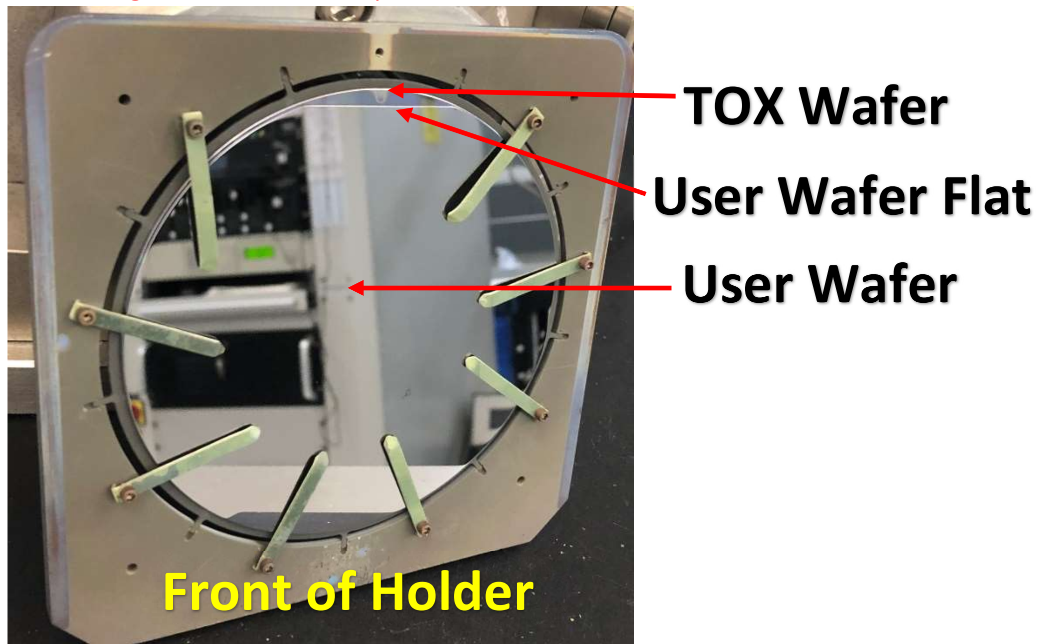
8. Mount your sample(s) on the holder:
   - For the non-heated holder, mount your sample(s) using the 3/32 Allen wrench/driver and copper samples clips as pictured below.



- For the heated holder, mount your samples or full wafer on the supplied TOX wafer. **Use the 1/16 Allen wrench/driver to loosen the Inconel clip screws and always use the blue handle torque driver to tighten them**. The Inconel sample clips must be in **all 8** positions as pictured below.



IMPORTANT: There is a 9th clip position circled in red above. DO NOT place a clip in this position as is will interfere with the thermocouple contact and damage it!
IMPORTANT: When running a full 4" wafer, the wafer must be mounted as follows or else damage to the thermocouple will occur!



9. Return the sample holder to its holding fixture. The heated sample holder must be slid in uniformly. If it gets stuck, slide it back out and try again.

10. If you are using the heated sample holder, you must install the heat shield. Use the 3/16 Allen wrench/driver and two ¼-20 hex head screws; one screw in the center position and another in the left position.

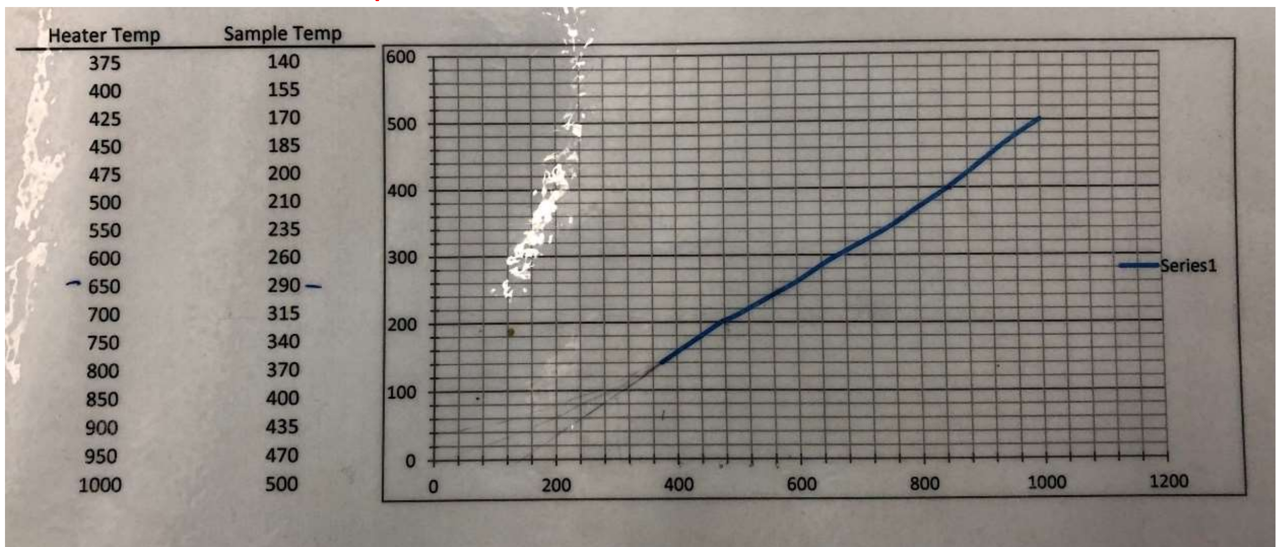
11. Inspect the sealing surface of the bell jar for any flaking or foreign material. Clean this surface with IPA and a wipe as needed.
12. Lower the bell jar by holding the BELL JAR toggle switch in the DOWN position, releasing the switch once the bell jar is seated against the sealing surface.
    NOTE: If for some reason the lowering of the bell jar is interrupted, do not continue to move it down. Return it to the upper stop point and then bring it back down.
13. Move the AUTO-CONTROL switch on the vacuum controller down to the START position to begin pump down of the chamber. After ~30 seconds the ROUGHING light will come on and the reading on Channel A of the VACUUM GAUGE CONTROLLER will begin to decrease. Once this reading gets down to around 7.0E-2 the ROUGHING light will turn off and the HI-VAC light will turn on. The Channel A reading will continue to decrease until it zeros out. After some time, the ion gauge should turn on automatically. If it does not, turn it on by pressing the IG1 button on the VACUUM GAUGE CONTROLLER.
14. You will now have to wait for the chamber to pump down to the process base pressure, which is typically <3.0E-6 on the ion gauge. This should not take more than an hour. If the base pressure for the ion gauge is still in the mid to high -6 range after an hour, perform the following:
    - Press the DEGAS button on the VACUUM GAUGE CONTROLLER, the LED on the button should illuminate.
    - Wait 30 seconds and press the DEGAS button again, the LED will go out.
    - The IG1 pressure reading will have risen during the degas but should begin to drop after the degas was stopped. Wait about 5-10 minutes and check the chamber pressure, if it is still not at or below 3.0E-6 contact Staff.

    NOTE: While the chamber is pumping down, you can proceed to Steps 22 – 26 and set-up your deposition parameters.
15. ~~Turn off the ion gauge by pressing the IG1 button on the VACUUM GAUGE CONTROLLER **prior to flowing any gas or starting a deposition**.~~

SAMPLE HEATING

16. Turn on the heater by increasing the temperature setting on the on the temperature controller. This is done by holding the + button until the desired temperature is reached in the Set Point field. Be aware that at first it will move in single digit increments, then double digit, and then triple digit. Once you have the temperature set, the Set Point field will flash and briefly highlight the setting and then the heater will begin to ramp to the set point.

IMPORTANT: The setting you set the heater to is not what the sample temperature will be, you will need to reference the **Temperature Offset Table.**



Heater Temp	Sample Temp
375	140
400	155
425	170
450	185
475	200
500	210
550	235
600	260
650	290
700	315
750	340
800	370
850	400
900	435
950	470
1000	500

OXYGEN GAS FLOW

17. Open the O2 ISOLATION VALVE. This valves goes from closed to open in a ¼ turn and can flood the chamber with residual gas from the line if it is opened quickly. Open the valve (counterclockwise) in thirds, waiting for the chamber pressure reading on the ion gauge ~~chamber gauge (left side of the chamber)~~ to drop or stabilize each time before proceeding.

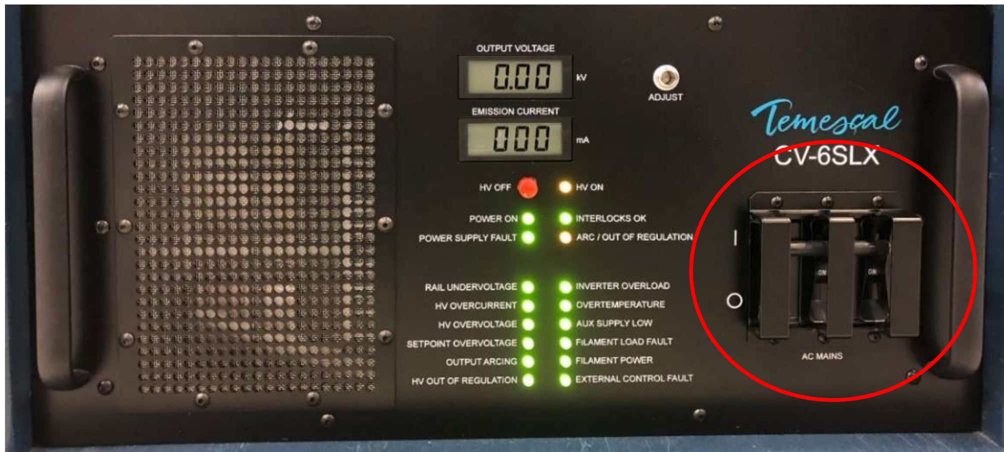
18. On the MKS Type 246 Pwr Supply Readout (gas flow controller), make sure the Set Point dial is at 0 (fully counter-clockwise) and the switch is set to Flow.

19. Move the other switch up to the On position and begin to introduce gas into the chamber by slowly turning the Set Point dial clockwise. When introducing gas into the chamber do it in increments of 5 SCCM at a time, waiting for the chamber pressure reading on the ion gauge ~~chamber gauge~~ to drop or stabilize each time before proceeding.
    IMPORTANT: The maximum flow rate you can run is 60 SCCM!

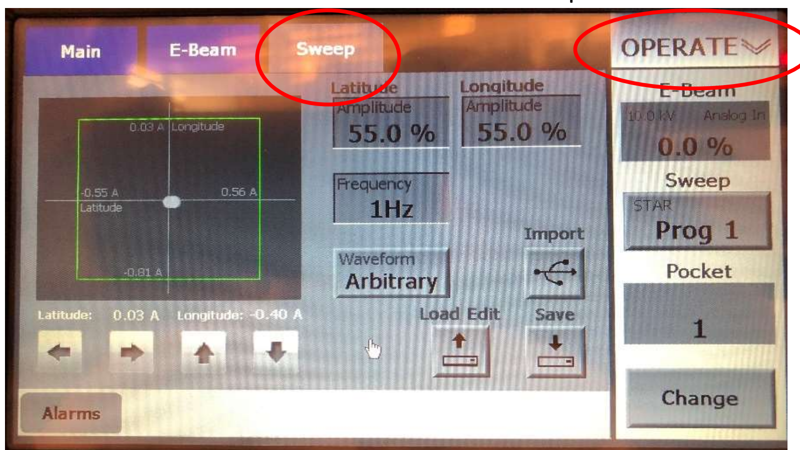
E-Beam #2 Operation

DEPOSITION

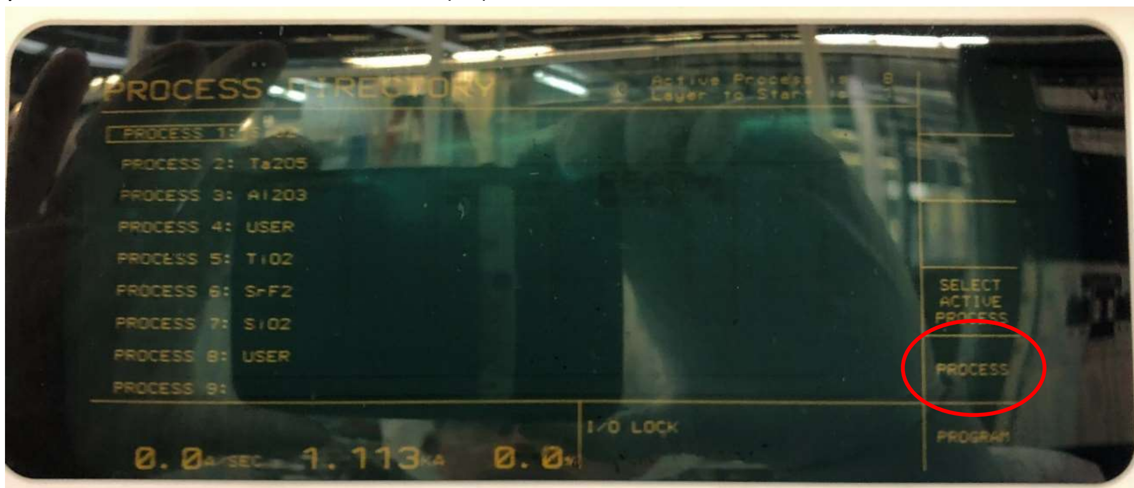
20. Turn on the circuit breaker on the Temescal CV-65LX high voltage power supply, located at the bottom of the electronics rack. You should see no red LEDs on the power supply, only green and orange. If you do see red LEDs, STOP and contact Staff.



21. Make sure the EBC is in OPERATE and the Sweep tab is selected.



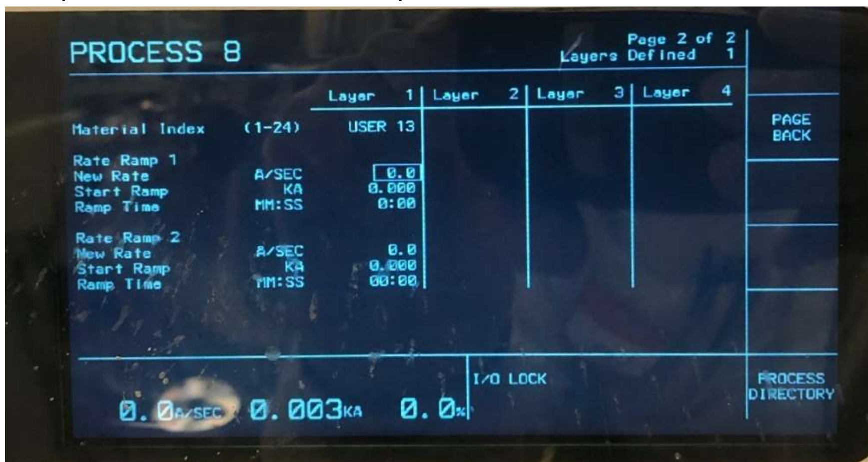
22. From the main OPERATE screen on the IC5, select PROGRAM (F6) and then select PROCESS DIRECTORY (F2). Using the arrow keys, scroll to the desired Process # that has the material(s) you want to run and select PROCESS (F5).



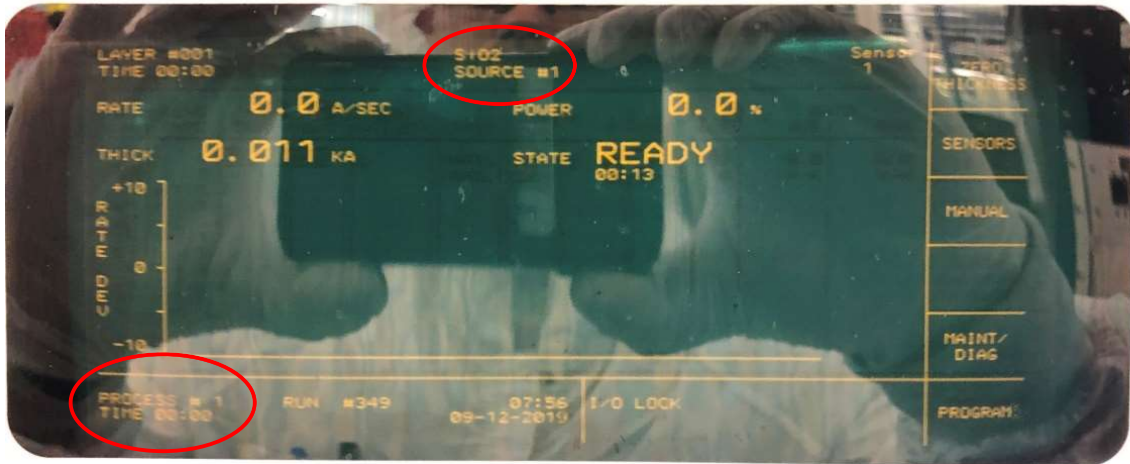
23. On the process screen, using the arrow keys, number pad, and E key (enter), enter the following:
    a. Rate in Å/sec
    b. Final Thickness in kÅ
    c. Thickness Limit in kÅ – This must match the Final Thickness
    d. Crucible (1 – 4), this is where you placed the source material (Crucible on the IC5 is the same as pocket on the EBC)

NOTE: Verify that the number next to the material (i.e. SiO2 1) is correct. The list posted at the system indicates which material numbers are configured with generic processing parameters that are for general use. In other words, there will be more than one of a certain material configured, but it will have a different number. Material #s that are not listed as generic are being used by a specific user or group. If this happens just return to the process list and find the process # that uses the correct generic material #. If you cannot find a process with the material # you require, you can either modify an existing process or create a new one. Just enter the material # you need in the Material Index field along with the other parameters listed above.

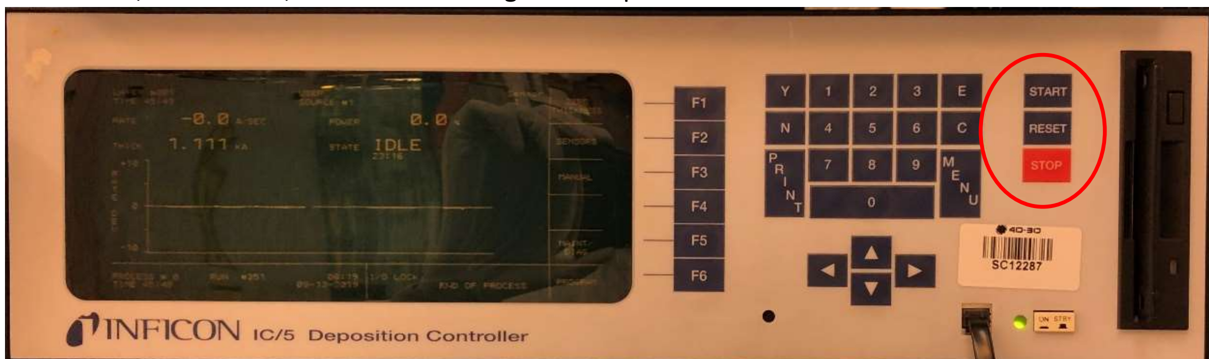
24. There is a second page of process settings that are accessed by selecting PAGE FORWARD (F1). This screen contains settings that allow you to ramp the deposition rate up or down for up to two defined thickness intervals during the deposition. It is recommended to check this page and verify all values are set to zero if you do not want to use this feature.



25. Select PROCESS DIRECTORY (F6) and then select SELECT ACTIVE PROCESS (F4).
26. Select PROGRAM (F6) and then select OPERATE (F6) to return to the main OPERATE screen.
27. Verify that the process # displayed in the bottom left hand corner of the screen is the correct process that you want to run. You can also verify the material at the top of the screen.



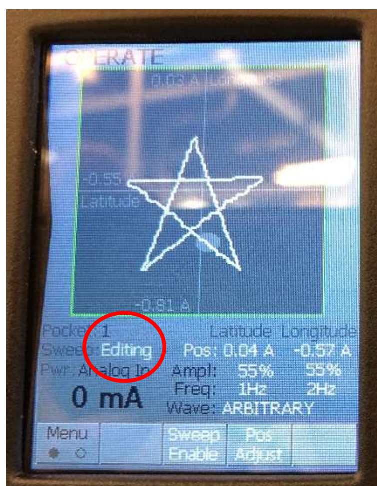
28. Press STOP, then RESET, then START to begin the deposition.

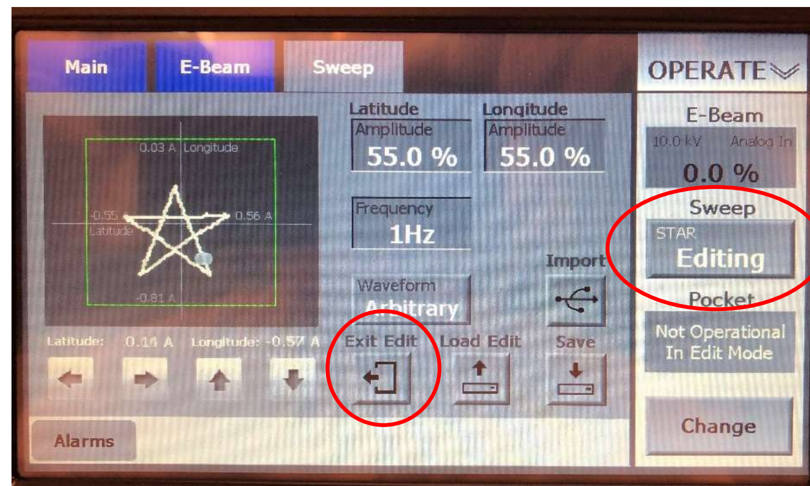


29. If applicable, wait until the EBC is on the correct pocket then if needed change the sweep program to the one you require. Do this by:
    e. Touch Change in the lower right corner, the sweep program field above will change to white.

f. Touch the Sweep field and a pop-up screen will appear. Enter the sweep program #, 1 - 5, then press Enter. The generic sweep programs for all pockets are:
    i. Program #1= Star
    ii. Program #2= Circle
    iii. Program #3= Smooth figure 8
    iv. Program #4= Sharp figure 8
    v. Program #5= Random pattern
g. Touch the sweep program box to turn on the sweep. The lettering will turn from black to white and the sweep pattern will appear on the EBC handheld and EBC screens (the Sweep tab must be selected on the EBC to see this).

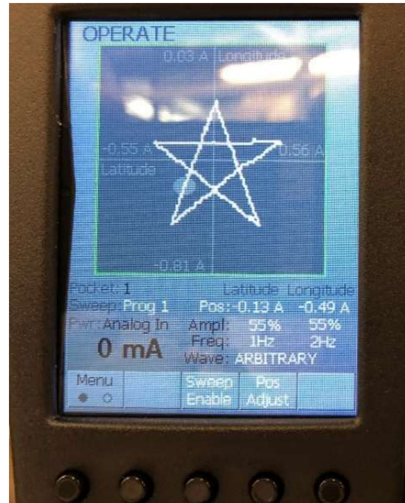
h. You are allowed to adjust the sweep parameters (size, shape, frequency and position), but you are not allowed to save your changes when you are finished. As soon as you make any change to a sweep program, both the handheld and EBC screens will read Editing. After your run is completed or if you decide to change the program, ALWAYS select Exit Edit to ensure the changes you made were not saved to the program.





Make sweep pattern changes by:

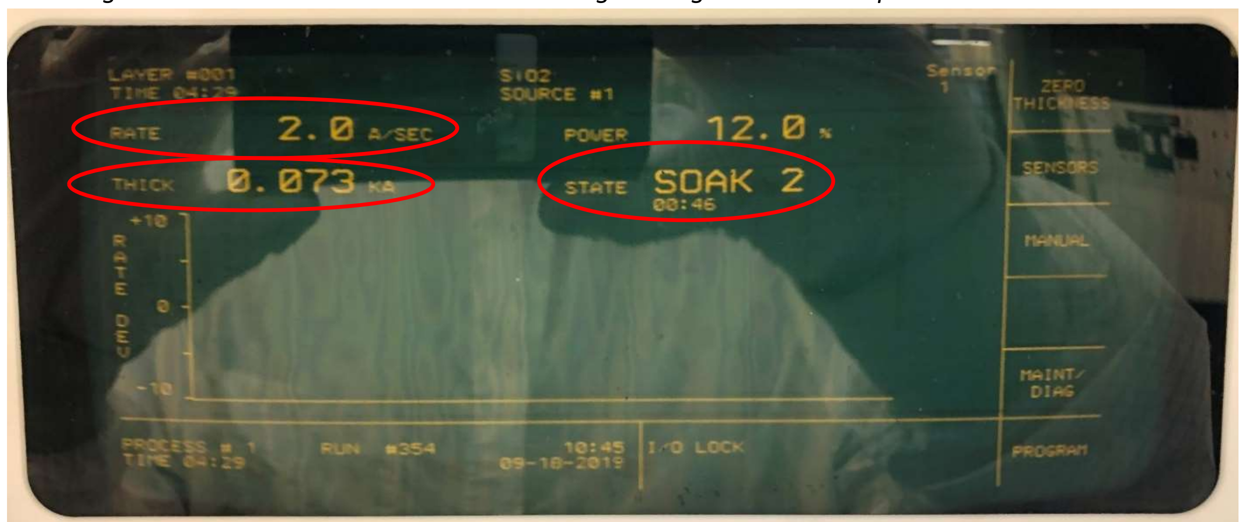
i. To change the beam position, use the handheld. Press the button below Pos Adjust, Pos Adjust lettering will change from black to white. You can now use the joystick to move the beam position.



ii. To change the latitude/longitude size and frequency, use the EBC touchscreen and touch the field you would like to adjust, a pop-up window will appear to enter the new value.
NOTE: If you adjust the size outside of the beam position limits, the pattern will be clipped.

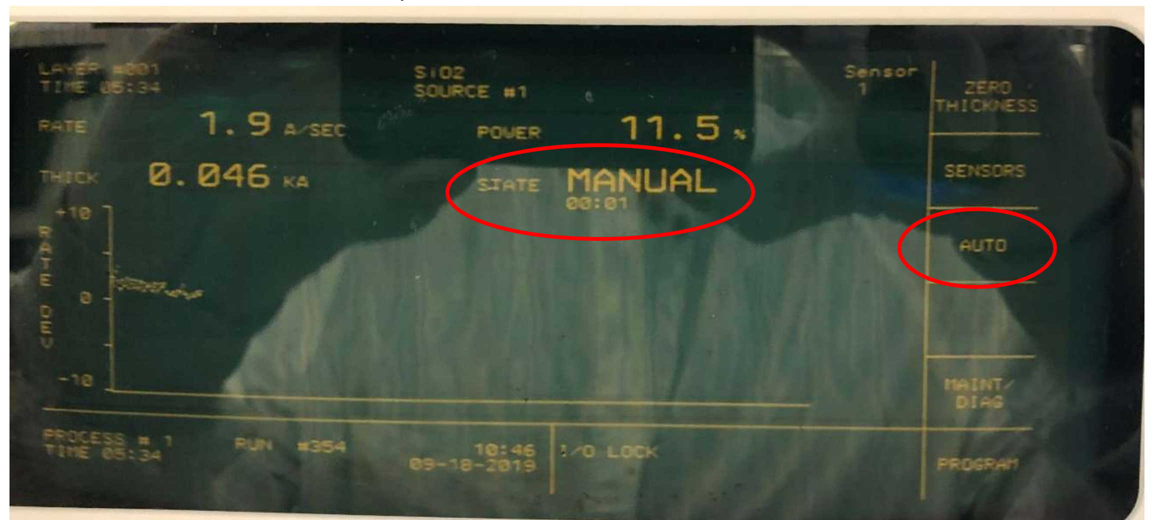
iii. To change the latitude/longitude shape, use the EBC touchscreen and just touch the Waveform button(s) to cycle through the available shapes.

30. Once you press START on the IC5, the selected process will begin. All generic processes are configured to run as follows: RISE 1→SOAK 1→RISE 2→SOAK 2→DEPOSIT. During the RISE steps the power will increase to a specified value over a specified time. During the SOAK steps the power will hold at that specified value over a specified time. You will begin see a RATE reading and the THICK reading will begin to accumulate during these steps. The THICK reading will be zeroed out once the DEPOSIT step begins.
The image below shows rate and thickness readings during the Soak 2 step.



31. Once the Deposit step begins, the shutter will open and the THICK reading will be zeroed out. The controller will begin adjust the power to achieved the rate specified in Step 22. Also, the Rate Dev line chart on the display will begin to graph in real-time.

32. Modifying the generic processes is not allowed, however a user can switch a generic process to manual mode if, for example, the system is taking too long to get the rate in control. This is performed as follows:
    i. Press MANUAL (F3). Once in manual mode the STATE on the display will change from DEPOSIT to MANUAL and the F3 panel will read AUTO.

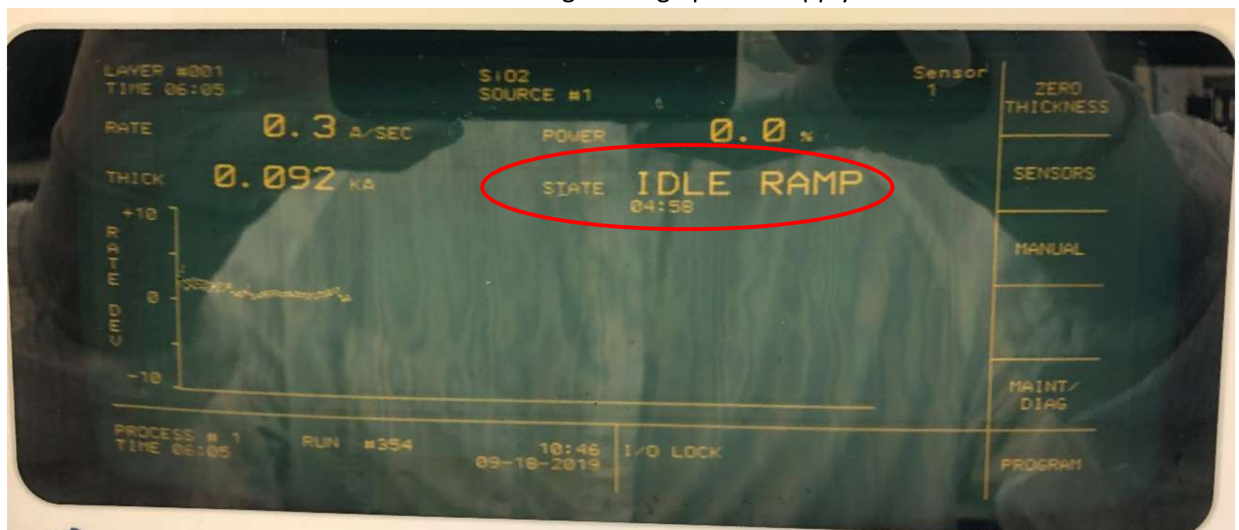


j. You can now control the power using the hand-held controller. Slide the switch on the top of the controller to the left (INCR) to increase the power and to the right (DECR) to decrease the power. Take care not to press down (STOP) on the switch as that will stop the deposition process.

k. Once you have the rate back in control, you can press AUTO (F3) and let the IC5 resume control.

NOTE: If you select MANUAL during any of the ramp or soak steps, the shutter will open and the deposition will begin. Once you switch back to AUTO mode you will be in the DEPOSIT state. Also when running in MANUAL, the deposition will not stop when the designated thickness has been reached. You must either return to AUTO mode or press STOP on the handheld to halt the process.

33. Once the set deposition thickness has been reached the shutter will close and the power will quickly ramp down. After that a 5-minute IDLE RAMP will begin. Once this is finished, turn off the circuit breaker on the Temescal CV-65LX high voltage power supply.



34. Turn off the ion gauge by pressing the IG1 button on the VACUUM GAUGE CONTROLLER. This is especially important if you are flowing gas as it will decrease the life of the ion gauge filament.
35. If you were running a heated sample, YOU MUST WAIT UNTIL THE TEMPERATURE IS BELOW 250°C BEFORE VENTING THE CHAMBER! Perform the following:
    l. Set the sample heat to 0°C per Step 18.
    m. Oxygen gas flow is typically used with heated sample runs, leave the gas flow on to help speed up the cool down.
    n. Once the chamber temperature is below 250°C, vent and open the chamber per Steps 1 – 4. If gas flow was used, turn it off before venting the chamber (see next step).
36. If you were using the oxygen gas flow, perform the following to stop the flow:
    o. On the MKS Type 246 Pwr Supply Readout, move the switch to the Off position and turn the Set Point dial to 0 (fully counter clockwise)
    p. Close the O2 ISOLATION VALVE by turning it clockwise to OFF.
37. You must now wait 10 minutes before venting the chamber or you risk oxidizing the E-gun filament. Vent and open the chamber per Steps 1 – 4.
38. Unload the sample holder, remove your samples, and return the sample holder to the chamber. If you were using the heated sample holder, DO NOT REMOVE IT BY HAND! as it is still very hot. Use the pliers at the system to remove the sample holder and set it on the non-heated sample holder, NOT ON THE WORK SURFACE AT THE TOOL!
39. If you are finished using the system, remove your source(s) per Steps 5.a – 5.c.
40. Close and pump down the chamber per Steps 10 – 12. You do not have to wait for the ion gauge to turn on but you should verify that the Channel A reading has zeroed before leaving the system.
41. Make sure to log your run in the log book with the following information:
    - Date
    - Name
    - Base Pressure
    - Material(s)
    - Dep Rate(s)
    - Approximate % Power to reach dep rate(s)
    - Heater Set Point (if used)
    - Dep Thickness(es)