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Lesker PVD75 E-beam/Thermal Evaporator (PVD-02) Standard Operating Procedure

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Lesker PVD75 E-beam/Thermal Evaporator (PVD-02) Standard Operating Procedure

Summary/Description

Standard Operating Procedure for the Lesker PVD75 E-beam/Thermal Evaporator (PVD-02) located at the Quattrone Nanofabrication Facility within the Singh Center for Nanotechnology at the University of Pennsylvania

Keywords

physical vapor deposition, e-beam evaporation, thermal evaporation

Disciplines

Condensed Matter Physics | Electronic Devices and Semiconductor Manufacturing | Engineering Science and Materials | Nanotechnology Fabrication

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Standard Operating Procedure (SOP)

Lesker PVD75 E-beam/Thermal Evaporator

(PVD-02)

Version 1.0.0, Updated 1/4/2023

In case of emergency, please call 911 (511 from a campus phone)

For any other major safety concerns, contact EHRS at: 215-898-4453 or via email: ehrs@ehrs.upenn.edu

If there is an error on the system/tool please report it on IRIS, and staff will address it

Please *DO NOT* run diagnosis without a staff member's approval

General safety tips and common mistakes

- Outgassing materials (such as oils, grease, and volatile organics; plastics and glues) and materials with a high vapor pressure (such as In, Zn, and Mg) are not allowed in the chamber.
- You must work with staff to obtain permission and develop recipes for any new materials.
- Use the grounding rod to make sure all components are grounded before touching inside the chamber.
- Clips are preferred for securing samples. Kapton may be used only if necessary.
- You must watch and pay attention to both the lab computer and the process chamber while the tool is running.
- Crucibles can be very hot after evaporation. Leave time for them to cool and handle them carefully.
- Make sure to pump down the chamber when you are finished
- This SOP is written to ONLY provide some key operational procedures in a step-by-step manner. Neither this SOP nor any other documentation is a substitute for training and qualification to use the tool.

Lesker PVD75 E-beam/Thermal Evaporator

E-beam Evaporation SOP

Thermal Evaporation SOP

Evaporation Overview

- Load sample and evaporation material
- Deposit films
- Wait for sources to cool
- Unload sample and deposition materials
- Vacuum any debris from chamber
- Pump down chamber

Procedure Overview

Materials

E-beam Evaporation Materials

- Pocket 1: Al, Pt, Pd
- Pocket 2: Ti
- Pocket 3: Ag, Au, Cu
- Pocket 4: Cr, SiO_2, Al_2O_3

Note: The e-beam sweep setting has been optimized to evaporate the listed materials in their specified pockets. Do not put materials in pockets where they do not belong.

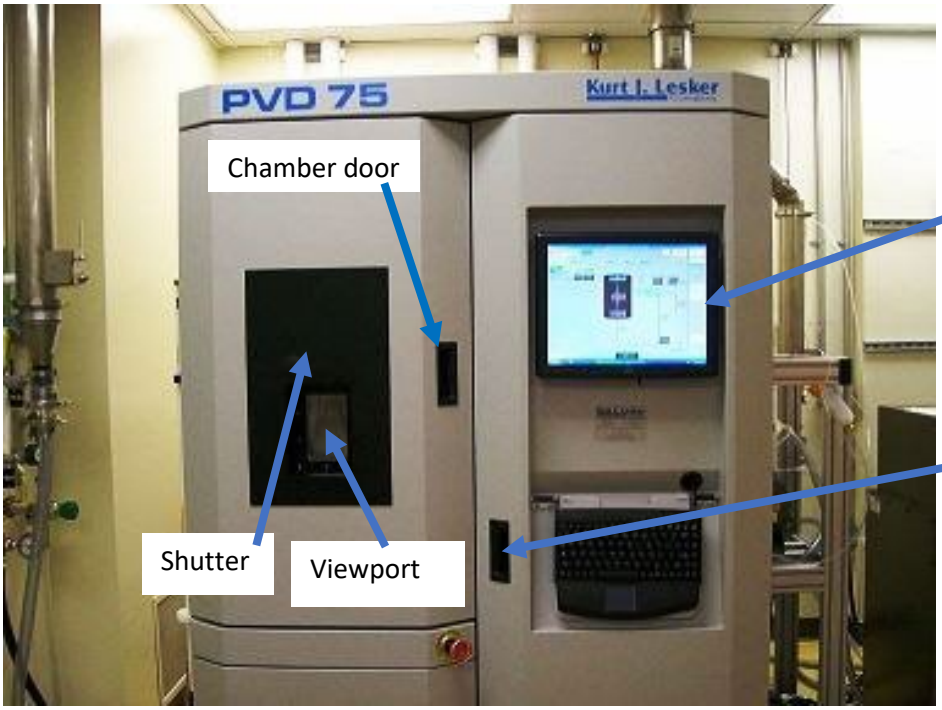
Thermal Evaporation Materials

Al, Ag, Au, Cr, Ni, Ti

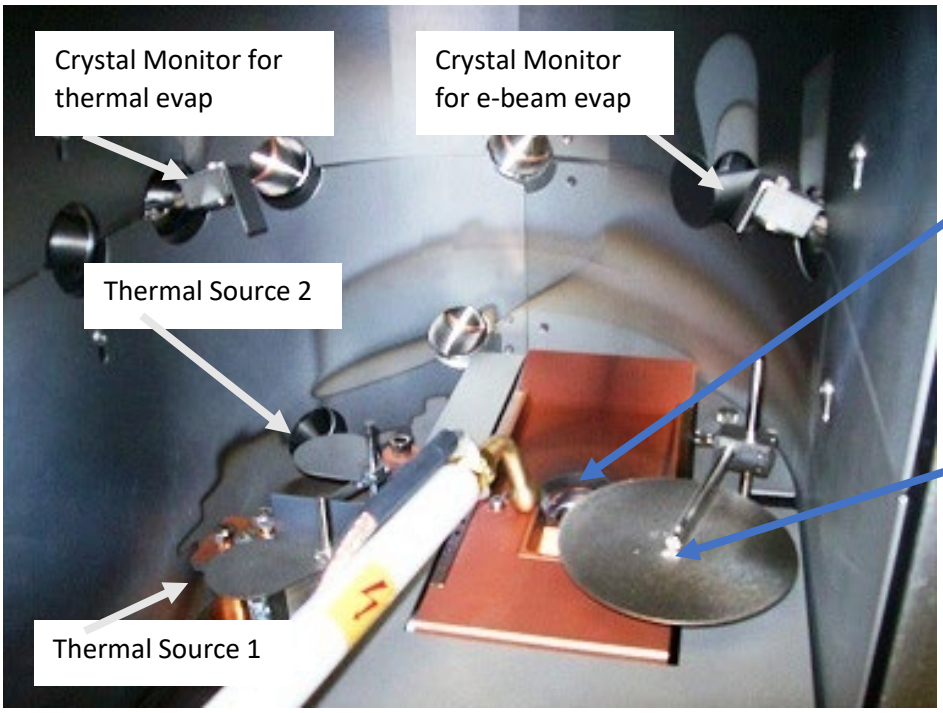
Other Materials:

Please work with staff to establish compatibility and develop a recipe before depositing other materials

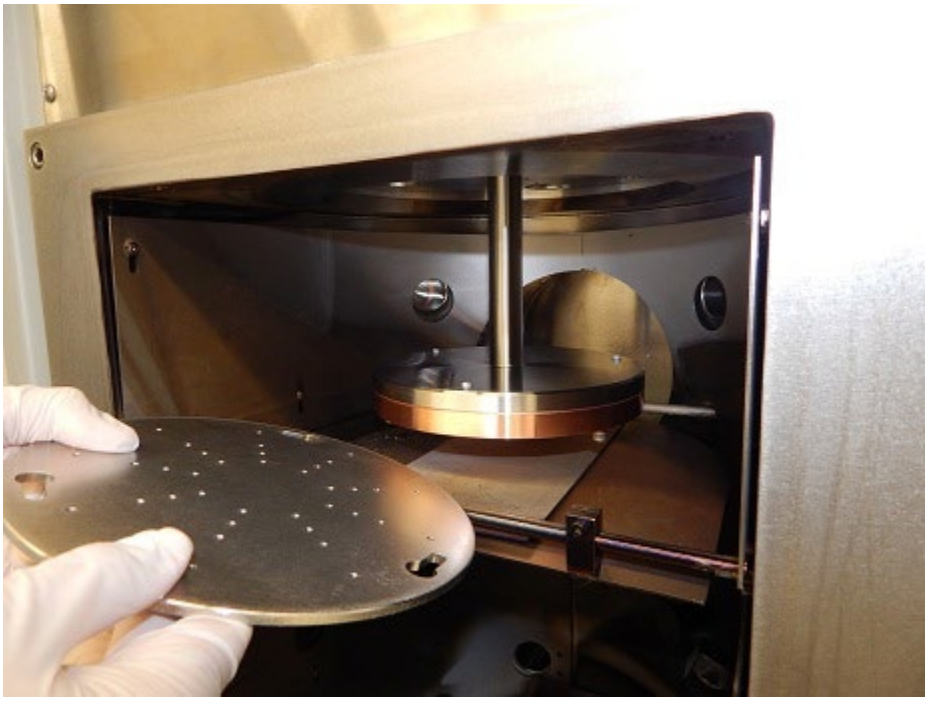
Hardware Overview



Sources



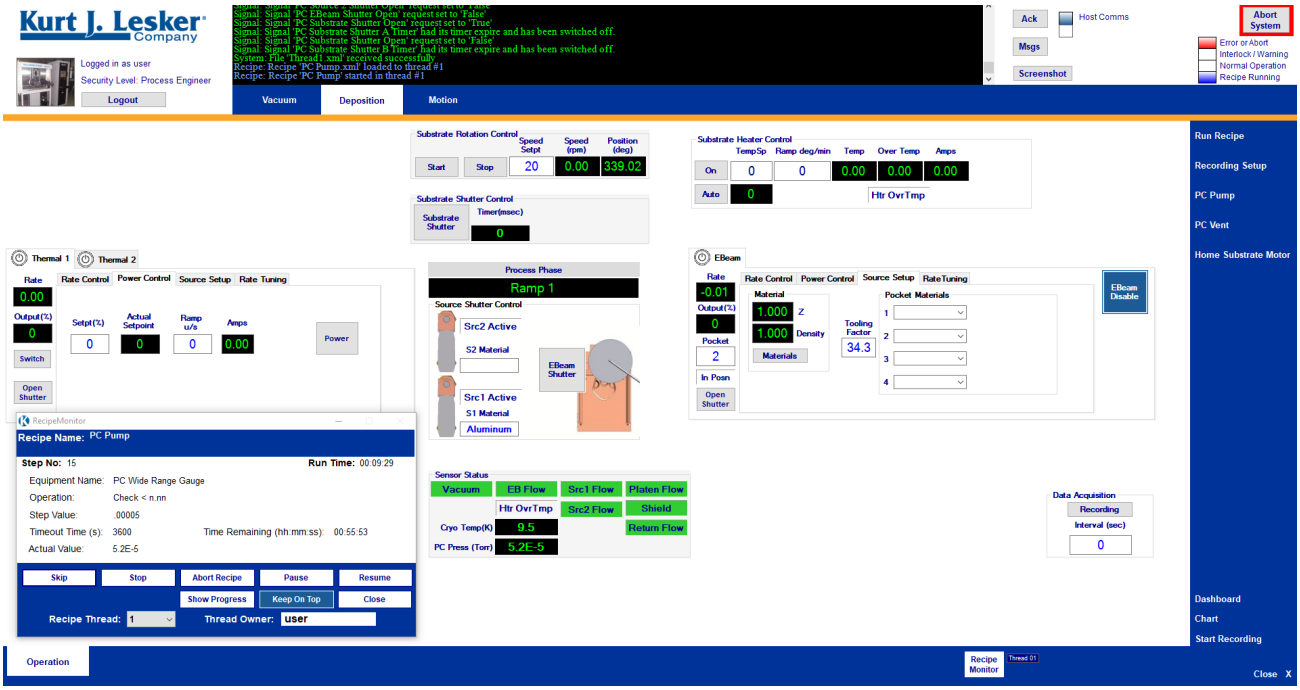
Sample Holder



Handheld Controller

Software Overview

Main Software



Recipe Monitor

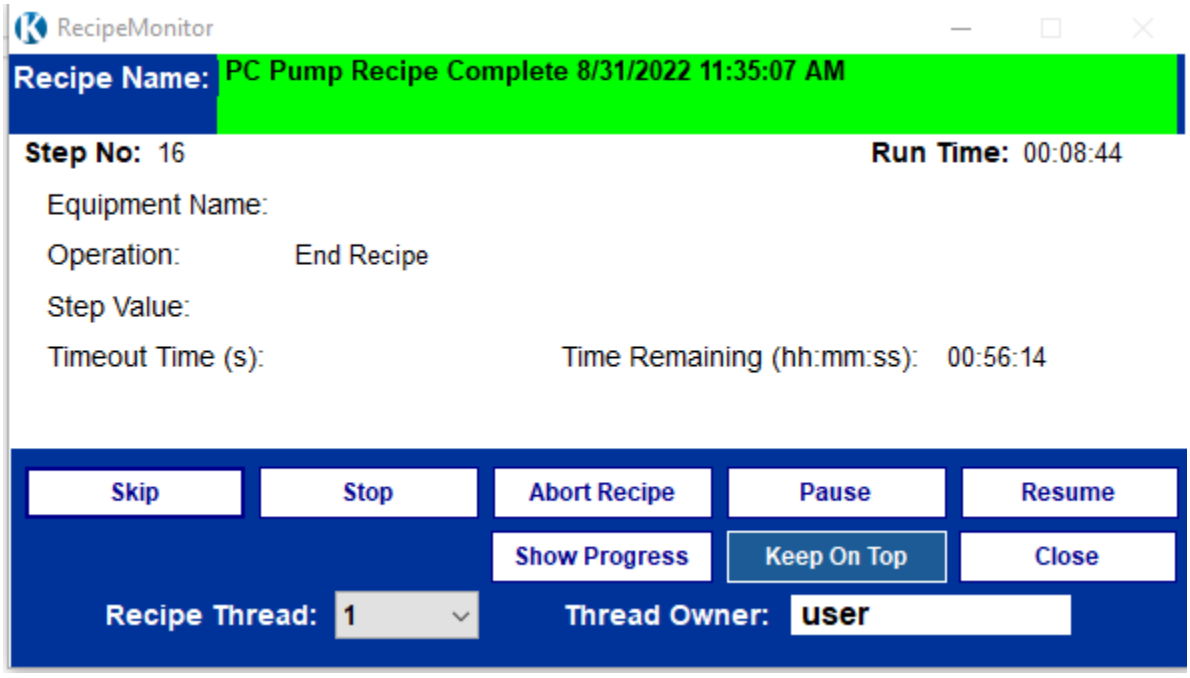
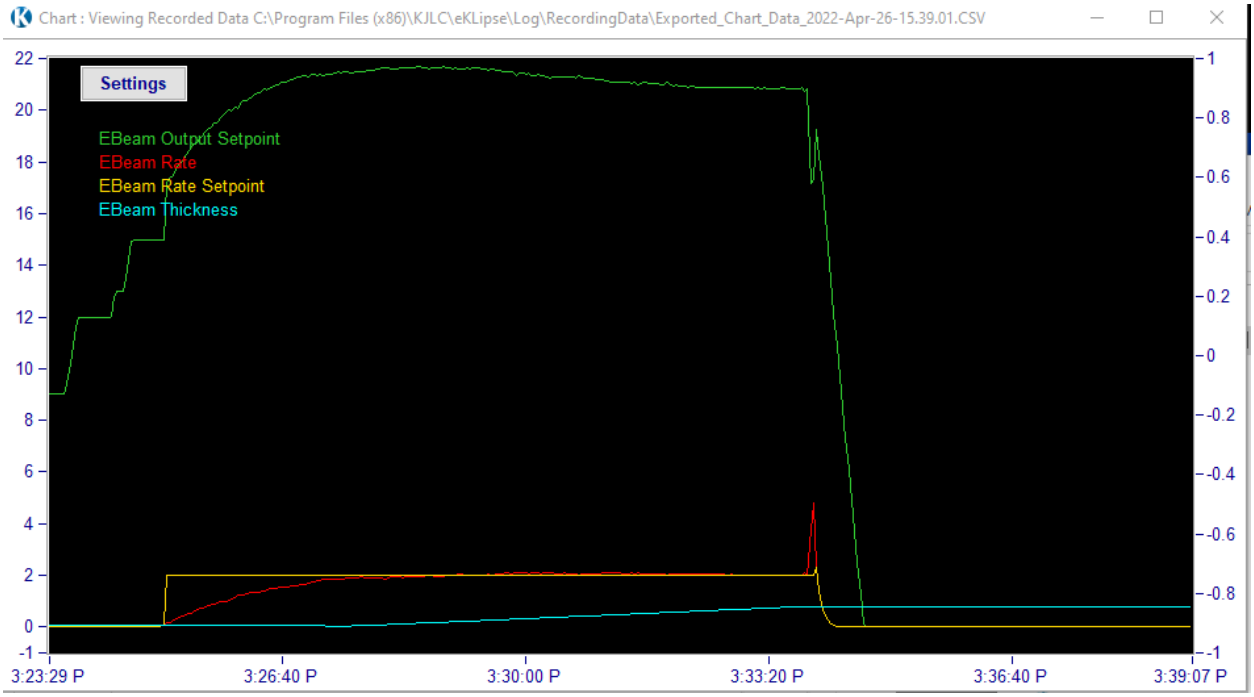
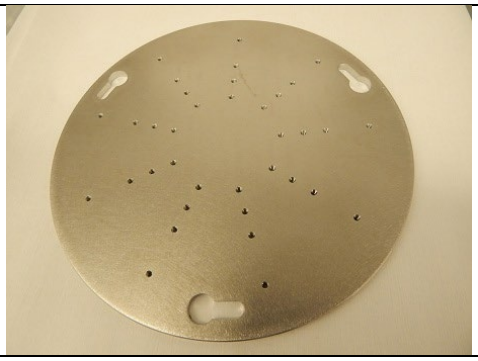
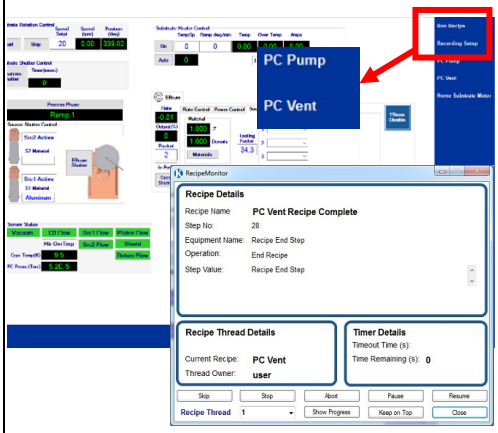


Chart Window



Full E-beam Evaporation Procedure

1. Sample Loading

1.0. Log into the tool via IRIS	
1.1. Mount sample **1.1.1.** Attach sample to desired sample holder **1.1.1.1.** Metal clips are preferred, but Kapton can be used if necessary **1.1.1.2.** Samples should be secure as holder is turned upside down when it goes into the tool	
1.2. Check that the tool is in a safe state to vent **1.2.1.** All deposition sources should be off for at least 5 minutes **1.2.2.** The E-beam power supply switch should be turned off **1.2.3.** The software should show the Vacuum page	
1.3. Vent the chamber **1.3.1.** Press the PC vent button on the right side of the screen **1.3.2.** The vent process takes several minutes **1.3.3.** When the recipe is complete, the recipe window will turn green, and the chamber door can be pulled open **1.3.4.** Use the grounding rod to touch around the e-beam source and gun	 

1.4. Check Kapton film in front of glass viewport

1.4.1. If the film is coated in metal and hard to see through, replace it with a new one

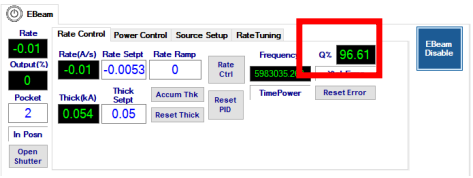
Note: It is not safe to deposit if you cannot see through the viewport!

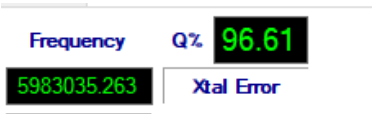
1.5. Check crystal monitor life (Q). Note that there are separate crystals for e-beam and thermal evaporation

1.5.1. Crystal lifetime can be found under 'Rate Control'

1.5.2. If it is below 30%, replace the crystal

1.5.2.1. See Appendix A for instructions on changing the crystal





1.6. Load sample holder

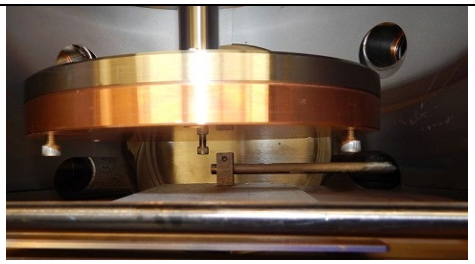
1.6.1. Pick up holder with sample facing down

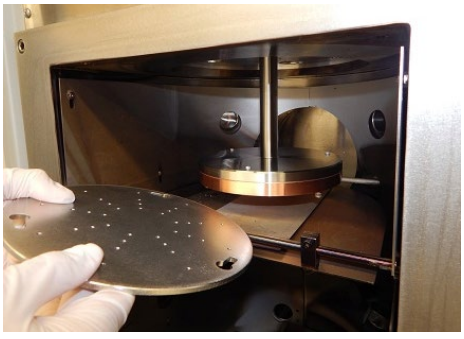
1.6.2. Line up with the large holes in the chuck with the bolts sticking down from the stage

1.6.3. Lift the holder so the bolt heads pass through the holes, and then rotate to seat the bolts in the narrow slots

1.6.3.1. It can sometimes be necessary to loosen the bolts to give space to rotate the holder into place

1.6.3.2. The platen is water cooled. If it is important that your sample is cooled, you must make sure that the sample holder is in tight contact with the platen by tightening the bolts.

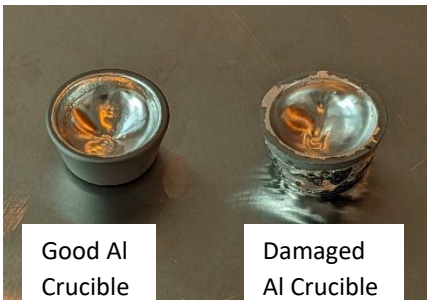




2. Loading Evaporation Materials

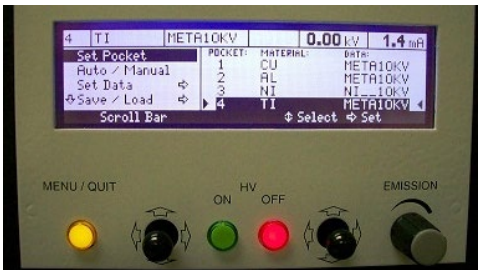
1.1. Prepare source material

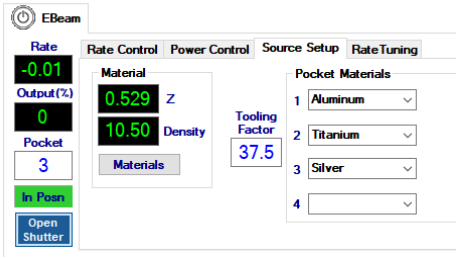
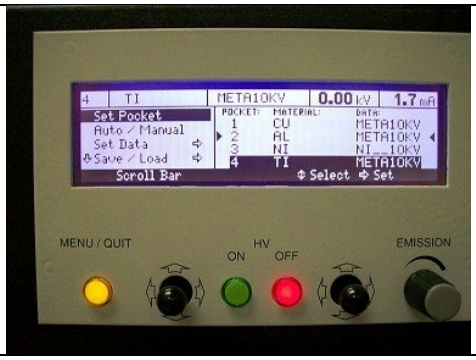
- **1.1.1.** Make sure crucible fill is sufficient (50-75% for most materials). It is not safe to deposit from an overfilled or underfilled crucible.
  - **1.1.1.1.** Some materials require extra care when melting in materials. Consult with staff if you are unsure.
  - **1.1.1.2.** For new crucibles, a melt should be formed in several steps
- **1.1.2.** Cracked crucibles should be avoided but can sometimes still be used. Crucibles with significant material spilled onto the outside should not be used.



1.2. Select pocket for material

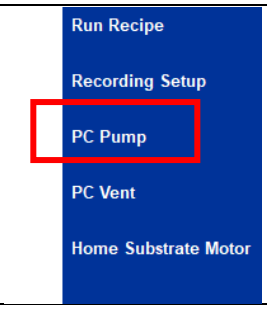
- **1.2.1.** Rotate the hearth carousel to reach the desired pocket
  - **1.2.1.1.** Open the right door of the tool to access the remote controller
  - **1.2.1.2.** Press the yellow 'Menu/Quit' button to activate the controller
  - **1.2.1.3.** Use the left joystick on the controller to navigate to the 'Auto/Manual' menu
  - **1.2.1.4.** Use the right joystick to switch from Automatic Operation to Manual Operation
  - **1.2.1.5.** Use the left joystick to navigate to the 'Set Pocket' menu
  - **1.2.1.6.** Use the right joystick to select the desired pocket
  - **1.2.1.7.** Hold the right joystick to the right and watch the carousel as it rotates. When it stops (and not before), release the joystick. The carousel will stop when the desired pocket is reached, but it will continue to rotate after a short while if the joystick is not released.



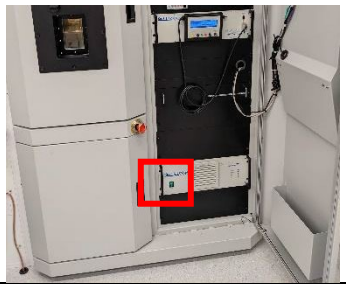
1.2.1.8. Make sure that the pocket number in the top left of the controller matches the desired pocket **1.2.2.** If a pocket jam error occurs and there is no obvious obstruction, it can usually just be cleared by pressing the 'Menu/Quit' button several times. If that does not work, try navigating to a different pocket and then return to the desired pocket	
1.3. Load crucible **1.3.1.** Carefully place correctly filled crucible into the pocket. It should fit snugly. If not, adjust it until it does. It may be necessary to use tweezers to scrape excess metal from the edge of the pocket. **1.3.1.1.** Crucibles that do not sit correctly will not be cooled correctly, and recipes will work very poorly	
1.4. Enter materials in Source Setup **1.4.1.** Select the correct material from the dropdown for the pocket into which the crucible was placed. **1.4.2.** **Recipes will not run properly if this is not selected correctly; this can damage the tool.**	
1.5. Repeat steps 2.1 to 2.3 for all desired materials	
1.6. Return the carousel to the position shown on the software **1.6.1.** If the actual position (shown on the controller) and the position in the software do not match, a Pocket Jam error will occur	

1.7. Return to Automatic mode on the controller **1.7.1.** Use the left joystick to select 'Auto/Manual' **1.7.2.** Use the right joystick to select 'Manual Operation' **1.7.3.** Press 'Menu/Quit' and close the right door	

3. Pump Chamber

3.1. Hold the chamber door closed, and press 'PC Pump' on the computer **3.1.1.** As soon as the chamber pressure starts to drop, you can release the door	
3.2. Wait for the chamber to reach a base pressure below $5x10^{-6}$ Torr **3.2.1.** This should take ~1 hour **3.2.2.** A lower base pressure will result in higher quality films	

4. Run Deposition Recipe

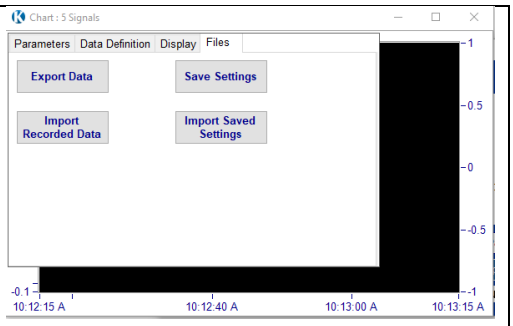
4.1. Turn on the e-beam power supply **4.1.1.** Open the right door and flip the green switch on the power supply at the bottom	

4.2. Start the chart

4.2.1. This will show a graph of power, rate, and thickness, which is key when monitoring the status of the deposition

4.2.2. Click the ‘Chart’ button, then ‘Load Parameters’, and select the saved parameters for e-beam deposition

4.2.3. The chart should always be running and visible when a deposition is running



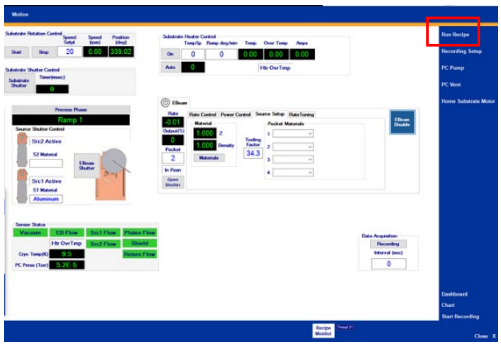
4.3. Run desired recipe

4.3.1. Go to the ‘Deposition’ page

4.3.2. Click ‘Run Recipe’

4.3.3. Select desired recipe from the list in the ‘RecipeSelector’ popup, and press ‘Run Recipe’

4.3.3.1. You should be picking a recipe that starts with “EBeam_Master”



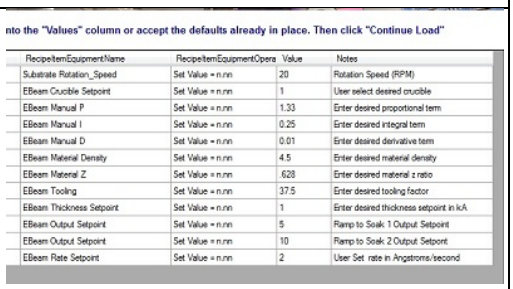
4.4. Choose deposition parameters

4.4.1. Recipes have a list of editable parameters

4.4.1.1. Desired thickness in kA always needs to be entered

4.4.1.2. Other parameters that may *sometimes* require changes are tooling factor, Soak 1 and Soak 2 power, and deposition rate. See appendix C for details

4.4.2. When all parameters are set, press ‘Continue Load’



4.5. Observe the process

4.5.1. The RecipeMonitor window will give information about the current step. Generally, e-beam evaporation recipes have approximately the following steps:

4.5.1.1. Startup – set all parameters and check status

4.5.1.2. Ramp 1 – Increase the power and begin to heat the melt

4.5.1.3. Soak 1 – Wait a fixed amount of time to allow the melt to stabilize. You should begin to see a melt (for materials that melt; for example, Cr does not melt)

4.5.1.4. Ramp 2 – Increase power to a second setpoint

4.5.1.5. Soak 2 – Allow the melt to stabilize again. This should bring the deposition rate near your desired rate

4.5.1.6. Shutter Delay – Open the source shutter (but not the sample shutter) and monitor the rate. PID control is used to automatically adjust the power to get the desired rate.

4.5.1.7. Deposition – Open the sample shutter and deposit the desired amount. Power continues to be automatically adjusted to maintain rate.

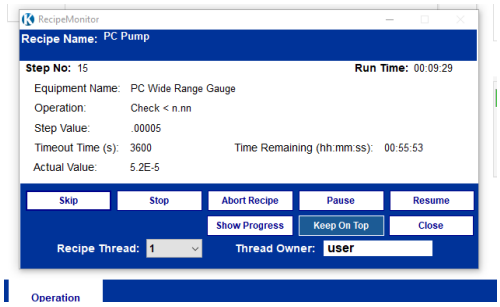
4.5.2. As the power ramps, open the shutter and look inside the chamber to see the crucible being heated

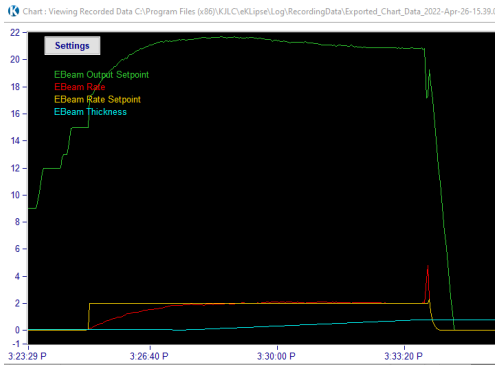
4.5.2.1. It should become clearly visible when the power is ~3%

4.5.2.2. If the e-beam spot is not hitting the evaporation material, abort the recipe and report an error

4.5.2.3. If the crucible fill level is too low and the e-beam spot is hitting the bottom of the crucible, abort the recipe

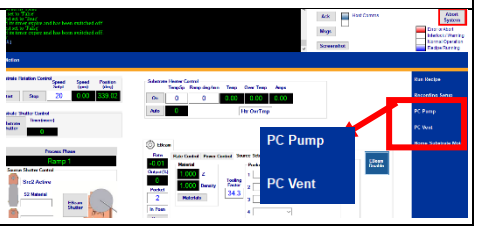
4.5.2.4. You should have a sense for how the crucibles should look and





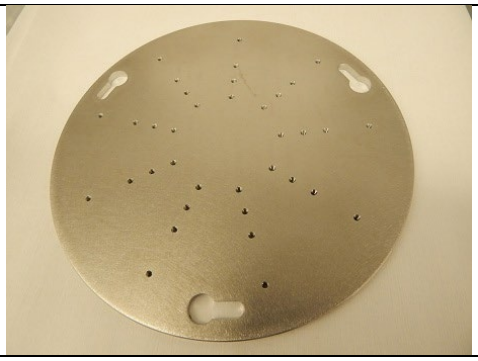
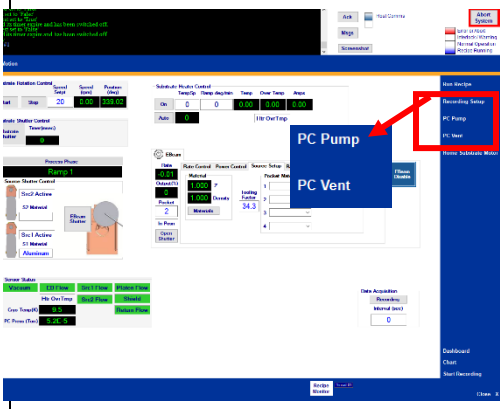
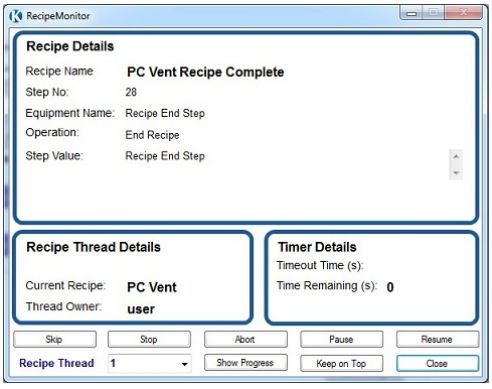
behave and be ready to stop the run if things do not look right **4.5.3.** Pay extra attention to both the PC and the chamber during the Shutter Delay step. **4.5.3.1.** Large oscillations to the power or rate mean the PID control is not optimized, and the deposition will likely fail **4.5.3.2.** If the desired rate cannot be reached during the shutter delay step, be very cautious about running the recipe again. This likely means that there is an issue with the crucible or recipe. Allowing it to fail this way multiple times will very likely destroy the crucible and could cause severe damage to the tool. **4.5.4.** You must always remain at the tool when the e-beam is on. **4.5.5.** If the recipe is not running as expected, it can be acceptable to press 'Pause' in the Recipe Monitor and assume direct control of the power and setpoints. Instructions for running the tool this way are in Appendix B	
4.6. Post deposition: Allow the source to cool **4.6.1.** After a recipe completes, wait until the crucible cools to the point that it is no longer visible through the viewport before depositing an additional film **4.6.1.1.** Moving the carousel with a hot crucible can cause a pocket jam	

5. Unload Tool

5.1. Wait until the tool has cooled down enough **5.1.1.** The crucible should be cool enough that you cannot see it through the viewport. Usually, ~5 minutes after the end of the deposition recipe is sufficient	
5.2. Vent Chamber **5.2.1.** Press PC Vent on the right side of the screen **5.2.2.** Wait until chamber is at atmospheric pressure (~7.6x10^2 Torr)	
5.3. Open door and unload **5.3.1.** Unload the sample holder and remove sample **5.3.1.1.** Make sure all tape is also fully removed from the sample holder if it was used. **5.3.2.** Carefully remove crucibles using tweezers **5.3.2.1.** Be careful as crucibles may be hot **5.3.2.2.** Two pairs of tweezers may be required	
5.4. Vacuum the chamber to remove any visible particles or flaking	
5.5. Pump down the chamber **5.5.1.** Close the chamber door **5.5.2.** Press 'PC Pump' while holding the door closed **5.5.3.** Wait until the crossover pressure has been reached and the cryo gate valve opens	
5.6. Log out of the tool on IRIS only after crossover pressure has been reached	

Full Thermal Evaporation Procedure

1. Sample Loading

Log into the tool via IRIS	
1.1. Mount sample **1.1.1.** Attach sample to desired sample holder **1.1.1.1.** Metal clips are preferred, but Kapton can be used if necessary **1.1.1.2.** Samples should be secure when holder is turned upside down	
1.2. Check that the tool is in a safe state to vent **1.2.1.** All deposition sources should be off for at least 5 minutes **1.2.2.** The E-beam power supply switch should be turned off **1.2.3.** The software should show the Vacuum page	
1.3. Vent the chamber **1.3.1.** Press the PC vent button on the right side of the screen **1.3.2.** The vent process takes several minutes **1.3.3.** When the recipe is complete, the chamber door can be pulled open **1.3.4.** Use the grounding rod to touch around the e-beam source and gun	

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Note: It is not safe to deposit if you cannot see through the viewport

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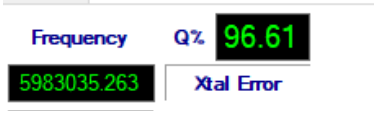

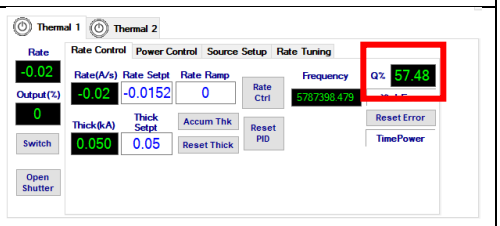

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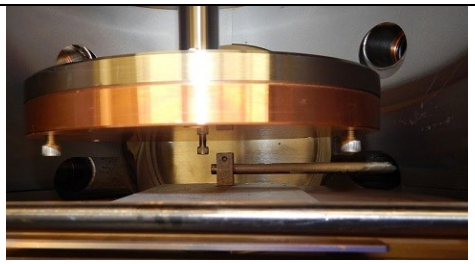
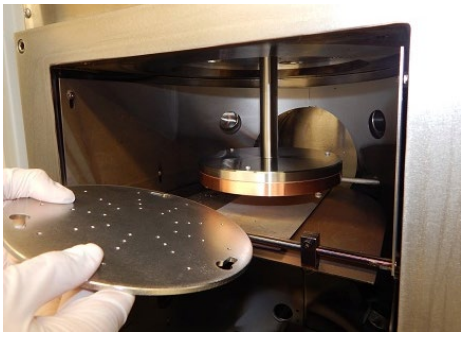
1.6.3.2. The platen is water cooled. If it is important that your sample is cooled, you must make sure that the sample holder is in tight contact with the platen.

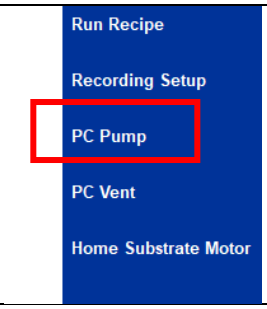




2. Loading Evaporation Materials

1.1. Load boat into desired source **1.1.1.** Make sure the boat is not cracked or shorted **1.1.2.** Open the source shutter **1.1.3.** Place boat between large spacers, making sure that it is level. If the boat is not level, the melted material will spill and possiblt cause a short. **1.1.4.** Gently tighten the clamps using the large hex wrench. Overtightening can cause the boat to crack. **1.1.5.** Close the shutter	
1.2. Enter materials in Source Setup **1.2.1.** Select the correct material from the dropdown for the source into which the boat was placed. **1.2.2.** **Recipes will not run if this is not selected correctly**	
1.3. Repeat steps 2.1 and 2.2 for the second source, if desired	

3. Pump Chamber

3.3. Hold the chamber door closed, and press 'PC Pump' on the computer **3.3.1.** As soon as the chamber pressure starts to drop, you can release the door	
3.4. Wait for the chamber to reach a base pressure below $5x10^{-6}$ Torr **3.4.1.** This should take ~1 hour **3.4.2.** A lower base pressure will result in higher quality films	

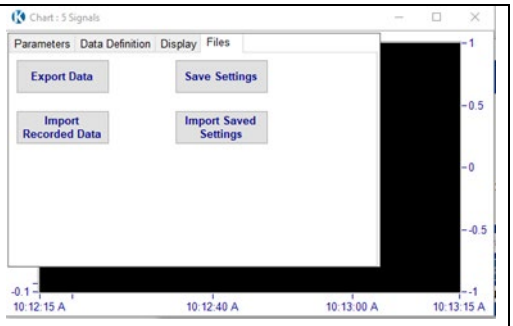
4. Run Deposition Recipe

4.7. Start the chart

4.7.1. This will show a graph of power, rate, and thickness, which helps to monitor the status of the deposition

4.7.2. Click the ‘Chart’ button, then ‘Load Parameters’, and select the saved parameters for thermal deposition

Note: each thermal source has a different saved set of parameters



4.8. Run desired recipe

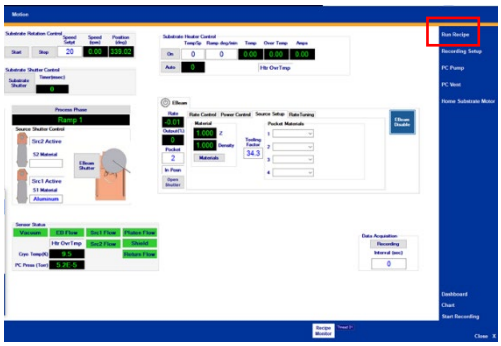
4.8.1. Go to the ‘Deposition’ page

4.8.2. Click ‘Run Recipe’

4.8.3. Select desired recipe from the list in the ‘RecipeSelector’ popup, and press ‘Run Recipe’

4.8.3.1. You should be picking a recipe that starts with “Master”

4.8.3.2. Make sure that the recipe is for the correct source



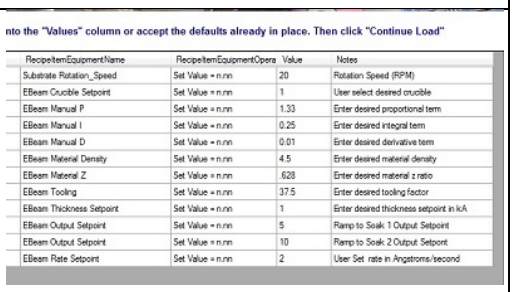
4.9. Choose deposition parameters

4.9.1. Recipes have a list of editable parameters

4.9.1.1. Desired thickness in kA always needs to be entered

4.9.1.2. Other parameters that may sometimes require changes are tooling factor, Soak 1 and Soak 2 power, and deposition rate

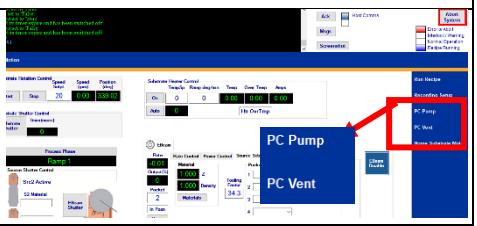
4.9.2. When all parameters are set, press ‘Continue Load’



4.10. Observe the process **4.10.1.** The RecipeMonitor window will give information about the current step. Generally, evaporation recipes have approximately the following steps: **4.10.1.1.** Startup – set all parameters and check status **4.10.1.2.** Ramp 1 – Increase the power and begin to heat the boat **4.10.1.3.** Soak 1 – Wait a fixed amount of time to allow the boat to stabilize. You should begin to see the material in the boat melting (for materials that melt) **4.10.1.4.** Ramp 2 – Increase power to a second setpoint **4.10.1.5.** Soak 2 – Allow the boat to stabilize again. This should bring the deposition rate near your desired rate **4.10.1.6.** Shutter Delay – Open the source shutter (but not the sample shutter) and monitor the rate. PID control is used to automatically adjust the power to get the desired rate. **4.10.1.7.** Deposition – Open the sample shutter and deposit the desired amount. Power continues to be automatically adjusted to maintain rate. **4.10.2.** As the power ramps, open the shutter and look into the chamber to see the boat **4.10.2.1.** You should have a sense for how the materials should look and behave and be ready to stop the run if things do not look right **4.10.3.** Pay extra attention to both the computer and the chamber during the Shutter Delay step. **4.10.3.1.** Large oscillations to the power or rate mean the PID control is not optimized, and the deposition will likely fail	

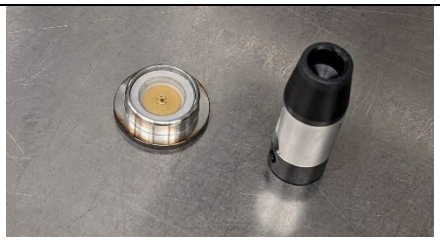
4.10.3.2. If the desired rate cannot be reached during the shutter delay step, be very cautious about running the recipe again. This likely means that there is an issue with the boat or recipe. Allowing it to fail this way multiple times can be harmful to the tool **4.10.4.** You must always remain at the tool when the power is on. **4.10.5.** If the recipe is not running as expected, it can be acceptable to press 'Pause' in the Recipe Monitor and assume direct control of the power and setpoints. Instructions for running the tool this way are in Appendix B	
4.11. Allow the source to cool **4.11.1.** After a recipe completes, wait until the boat cools to the point that it is no longer visible through the viewport before depositing an additional film **4.11.2.** Before venting, at least 5 minutes is recommended	

5. Unload Tool

5.7. Wait until the tool has cooled down enough **5.7.1.** The sources should be cool enough that you cannot see it through the viewport. Usually, ~5 minutes after the end of the deposition recipe is sufficient	
5.8. Vent Chamber **5.8.1.** Press PC Vent on the right side of the screen **5.8.2.** Wait until chamber is at atmospheric pressure (~7.6x10^2 Torr)	
5.9. Open door and unload **5.9.1.** Unload the sample holder and remove sample **5.9.1.1.** Make sure all tape is also fully removed from the sample holder **5.9.2.** Carefully remove boats **5.9.2.1.** Be careful as they may be hot	
5.10. Vacuum the chamber to remove any visible particles or flaking	
5.11. Pump down the chamber **5.11.1.** Close the chamber door **5.11.2.** Press 'PC Pump' while holding the door closed **5.11.3.** Wait until the crossover pressure has been reached and the cryo gate valve opens	
5.12. Log out of the tool on IRIS only after crossover pressure has been reached	

Appendix A: Changing the Crystal Monitors

The tool uses quartz crystal monitors to monitor the deposition rate (and therefore the thickness of material deposited). The crystal monitor on the right is for e-beam evaporation, and the crystal on the left is for thermal evaporation. The crystal associated with your desired process should be changed before using the tool if its lifetime is below 30%.

A.1. Grip the crystal retaining ring by the edge and gently pull down to release it	 
A.2. Use the crystal replacement tool to remove the back plate **A.2.1.** Gently push the narrow end of the tool into the back plate **A.2.1.1.** It can be helpful to gently twist the tool counterclockwise **A.2.2.** The back plate should come out with the tool	 

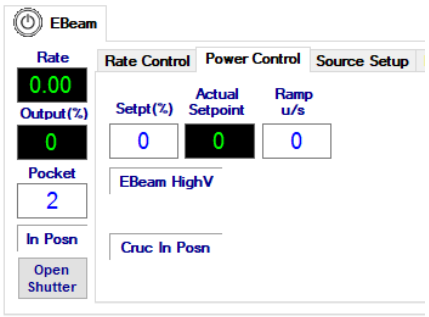
A.3. Remove and discard the old crystal in the sharps container found by the entrance to the bay. **A.3.1.** The crystal will be loose and will fall out easily	
A.4. Put a new crystal in place **A.4.1.** PVD-04 and PVD-02 use different crystals, so make sure to use the ones labeled “PVD-02” **A.4.2.** Remove the crystal from the container carefully and place it with the solid gold side down in the retaining ring	
A.5. Replace the back plate **A.5.1.** Use the tool to push the back plate tightly in place **A.5.1.1.** It can be helpful to gently turn the tool clockwise **A.5.2.** The plate should stay behind when you remove the tool	
A.6. Snap the assembled retaining ring back into the housing inside the chamber **A.6.1.** **Do not twist it!** **A.6.2.** Sometimes it is necessary to reset the crystal error in the software **A.6.3.** Make sure the crystal lifetime reading in the software is ~99% (6 MHz)	

Appendix B: Semiautomatic Operation

If necessary, it is allowed to pause the recipe and manually control certain tool parameters in order to run the recipe in semiautomatic mode. Some instances when this might be necessary are:

1. If you are refilling or building a new crucible and the power requirements are different from those in the standard recipe
2. You'd like to try a rate more than a few Å/s different from the one in the recipe
3. If you are developing a recipe for a new material
4. If, while running the recipe, you can see that the recipe is unstable or will not work successfully. In this case, you should be extremely cautious and make sure that the instability isn't caused by a more fundamental problem that will cause the deposition to fail or the tool to be damaged regardless of the parameters chosen.

Specifics of this procedure depend heavily on the reason for using it and the details of the process, but below is a generic example. These instructions are for e-beam evaporation, but the same basic procedure can also be used for thermal evaporation. **Consult with staff if you're unsure how to do this.**

B.1. Run a recipe for the material you intend to deposit **B.1.1.** Set the soak power values to be low (~1-3%) **B.1.2.** During soak 1, hit the pause button on the recipe monitor	
B.2. In the 'Power Control' tab under 'EBeam', control the power and ramp setpoints manually **B.2.1.** Make sure these are reasonable numbers for your material. If you're unsure, keep the ramp below 0.1 %/s. **B.2.2.** You must continuously monitor the chamber during this process. Be especially careful of the chamber pressure rising and spitting from the crucible **B.2.3.** To check the rate, open the source shutter under 'EBeam'. **B.2.3.1.** It's ok to leave this shutter open, but it can cause the crystal to degrade rapidly, so it's better if it is closed when a rate reading is not needed.	

B.3. Once you are satisfied with the precondition you can begin deposition

B.3.1. To return to automatic control, you can unpause the recipe

B.3.1.1. You will likely want to skip the soak and ramp steps and proceed to the shutter delay step

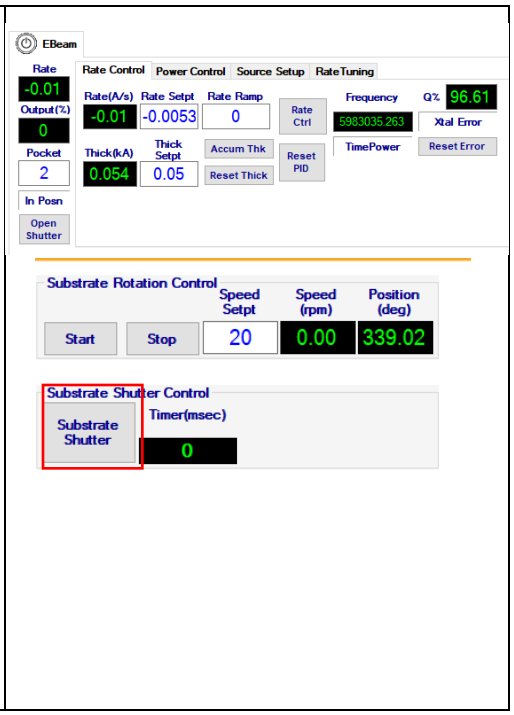
B.3.2. You can also continue manually instead

B.3.2.1. To run in manual mode, go to the 'Rate Control' tab

B.3.2.2. Press 'Reset Thick'

B.3.2.3. Press 'Accum Thk' and immediately open the substrate shutter

B.3.2.4. When the desired thickness is reached, close both shutters, ramp the power down to zero (at a reasonable rate), and abort the recipe



Appendix C: Choosing E-beam Deposition Parameters

An automated evaporation recipe should consist of the following steps:

1. **Ramp 1** – a ramp at a specified rate to a set power, at which the deposition material should begin to melt. The power here is a critical parameter that depends on the material, crucible, and other factors.
2. **Soak 1** – A delay, during which the power is held constant, to allow the deposition source to reach thermal equilibrium. The length of the soak depends mostly on the thermal properties of the material.
3. **Ramp 2** – A ramp at a specified rate to a set power, at which deposition at a reasonable rate should occur
4. **Soak 2** - A delay, during which the power is held constant, to allow the deposition source to reach thermal equilibrium. The length of the delay depends mostly on the thermal properties of the material.
5. **Shutter delay** – The source shutter is opened, but the substrate shutter remains closed. The deposition rate is monitored with the crystal monitor. PID control is used to adjust the power to bring the deposition rate to the setpoint. If it is very far from the setpoint at the start of the shutter delay, the control loop may work very poorly and cause damage to the crucible.
6. **Deposition** – The substrate shutter is opened and material is deposited on the sample. The power is continuously adjusted using PID control to maintain the desired rate.
7. **Ramp down** – When the desired thickness is reached, the substrate and source shutters close. The power ramps down at a set rate. This rate depends on the material properties. Cooling too fast can often damage or destroy crucibles.

Other important considerations:

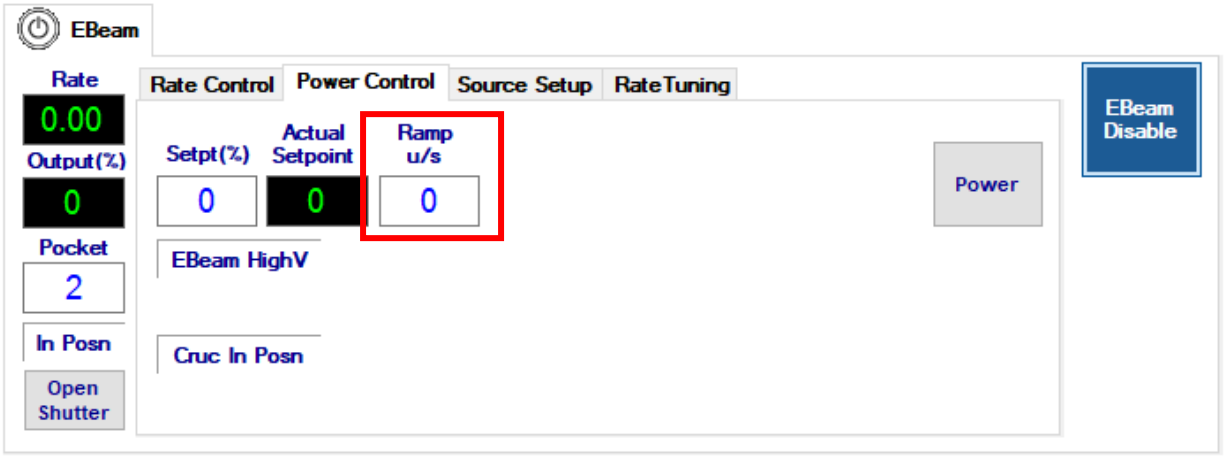
Beam sweep – Electromagnets can be used to scan the beam over the source material during deposition. This effectively broadens the deposition source from a point to some area (which is not usually desirable), but depending on the material, it can be necessary to achieve stable high-quality deposition. For materials with good thermal conductivity like Au, Ag, Cu, Al, etc., a sweep is not advised. For materials that don't melt (and therefore do not transfer heat much at all) like Cr and most dielectrics, a broad sweep covering the whole pocket is necessary, and severe damage can result if the beam is not swept. For other materials that do form a melt but have poor thermal conductivity like Pt, Pd, and Ti, a small sweep can often improve the deposition quality and crucible health, usually at the cost of slower deposition rates or higher required powers.

Beam sweep cannot be adjusted by users, but be aware that pockets 1-3 are set up to have no sweep, and pocket 4 has a wide, full pocket sweep.

HV – The potential of electrons used for deposition affects the results in a variety of ways (some obvious and some not). It cannot be configured by users, but be aware that pockets 1-3 are configured to run at 10 kV, while pocket 4 is configured to run at 6 kV.

PID Parameters – Choosing appropriate PID settings for a well-controlled recipe is a complicated issue, the details of which are beyond the scope of this SOP. If you believe PID settings need to be adjusted, please work with staff.

Ramp Rates – Ramp rates in PVD-02 recipes can only be configured in the recipe editor (not at runtime), which is not accessible to users. They can be manually controlled in the 'Power Control' tab in deposition. Ramping too fast can cause spitting of material and damage to crucibles. Sensible values depend on the material and pocket configuration, so please work with staff if you believe these values need to be adjusted.



Version History

Draft	*Date*	*Author*	*Notes on changes*
v.0.1.0	12/22/2022	David Barth	First Draft
v.0.1.1	2/21/2022	Jason Rohr	Edits
v.1.0.0	1/4/2023	David Barth	Finished Draft