

# Angstrom Engineering – EvoVac Evaporator

#### Introduction to e-Beam Evaporation

- <u>Angstrom Engineering e-Beam Overview</u>
- Angstrom Engineering Ion Assisted e-Beam Overview
- Denton Vacuum e-Beam Overview

#### Safety

- This tool contains high voltage sources and there are trip hazards behind the tool. Do not go behind the tool, attempt to open covers, or work inside the tool.
- Use caution when using the step ladder to load your wafers.
- Do not pinch your fingers in the chamber door or with the load lock lid.
- Do not bump your head when the door is open.
- The inside of the tool can get very hot, particularly the ion source and the crucibles. The substrate temperature reading is not accurate, so test the substrate holder before picking it up.
- Shutters in the tool can snap shut.
- The e-beam source can get very bright. Use the built-in filter to protect your eyes if necessary.
- Do not abrasively scrub the sample holder. It is made of molybdenum.
- If you open the chamber and it is flaking badly (i.e. small aerosols, not big flakes), close the door, leave and inform staff.
- Ground out the high voltage feedthroughs after opening chamber.
- In case of immediate electrical, chemical, or physical danger utilize the red EMO button situated on the front of the equipment.

#### **Allowed Materials and Processes**

- Aluminum, aluminum oxide, silicon dioxide, titanium, titanium nitride, and titanium oxide.
- To add new materials to this list, please email <u>andrew.lingley@montana.edu</u>.

#### **Restricted Materials and Processes**

- Do not attempt to make your own recipes without extensive training and explicit permission from the lab manager.
- Never change the sample stage.



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#### **Important Equipment Notes**

- Do not run "Transfer from Dep" when the substrate holder is in the load lock or "Transfer to Dep" when the substrate holder is in the deposition chamber. Either of these operations will damage the tool.
- Always hit "Load Recipe" after selecting a recipe from the dropdown or browse menus and verify that the recipe loaded correctly by looking at the "Recipe" cell on the upper left of the "Process" screen.
- Do not run a deposition without the sample holder in place. The substrate heater will get coated, and we will charge you for a new heater and the time to install it.
- Do not bump or run into the plumbing to the left of the tool.
- Do not bump or turn the black knobs on the Angstrom EVA power supplies.
- Except for the Chamber Light, do not operate the overrides in the System menu. Do not operate the servos manually.
- Make sure you have the correct material selected so you do not deposit the wrong one.

### **Operating Procedures**

- 1. Check reservations and make one: <u>https://www.montana.edu/cpa/apps/mmf\_tools/</u>.
- 2. Check tool status, visit: http://www.mmf.montana.edu/equipment-status.html.
- 3. Check the lab status.
  - a. Check N<sub>2</sub> bottle pressure. If it is below 500 PSI, inform staff, but continue operation as normal. If it is below 200 PSI, inform staff and wait for staff to change the N<sub>2</sub> bottle.
  - b. Check that the  $N_2$  is on for lab.
- 4. Check the equipment status.
  - a. Click the "System" button and then click the "Vacuum System" tab on the left. Then click on "Dep Chamber." Check Dep Pressure in the upper right of the screen. If it is above 8e-7 Torr, inform staff and leave a note on the tool marking it as inoperable. Check that the Cryo Temperature reads below 20 K.
  - b. Check that the pressure on the chiller located in the service area is 50±10 PSI by pressing the down arrow on the chiller once. If it is not, report to staff and leave a note on the tool that it is inoperable.
  - c. Check if the load lock is vented by trying to open the lid. If it opens, inform the lab manager, and then continue as normal.
  - d. Check that the Telemark Digital Sweep (instrument with the kangaroo on it) reads "Remote Off". The green light to the right of the display should be on that reads "REMOTE CONTROL." If the screen reads "Remote On" and the "REMOTE CONTROL" LED is off, press "Remote On."
- 5. Check the tool configuration
  - a. Click "Main" and then click "Load Materials". Check that the materials you need are loaded.



- b. Verify that the gas you need for the ion source is selected with the two-way valve on the wall to the left of the tool. If you need the other gas, work with the staff.
- c. Click System, Pressure Control, and verify that the Current Gas in MFC 2 Ion Source is the correct gas for your process. If you need a different gas, work with the staff.
- 6. Load materials (Optional)
  - a. Click System, Vacuum, and Dep Chamber. Verify that at least 5 minutes have passed since the last deposition and that the substrate has cooled below 50 C. Press Vent and Start. Wait about five minutes for the chamber to vent and open the chamber door. When you open the door, all the sources will turn off and the air pressure to the shutters will bleed off. Ground out the high voltage feedthroughs with the grounding rod. The tool will also throw a fault that cannot be cleared while the door is open.
  - b. Click Main and Load Materials to see what materials are currently in the pockets. Navigate to the pocket you want to change or refill by clicking on the pocket number and then hit "Move to Pocket".
  - c. Physically rotate the source shutter backward and out of the way. Take out the material using tweezers and be very careful that the crucible is not still hot. Do not ding the crucible with the tweezers.
  - d. Vacuum out the tool and crucible carefully to make sure there are not any pieces of material that will prevent the crucible liner from fitting snugly. Also vacuum out below the crucible to make sure there aren't any flakes that will short the filament.
  - e. Refill or change the material and reload the crucible into the crucible. Do not overfill the crucible; except for SiO<sub>2</sub>, crucibles should never be more than <sup>3</sup>/<sub>4</sub> full. Make sure the crucible is entirely in the pocket and sitting flat.
  - f. Update the Load Materials section. If you are not changing the material type, reset the Accumulated Power. If you are changing materials, you will be prompted to reset the Accumulated Power after you select a new material.
  - g. Wipe the sealing surfaces with a dry wipe and close the door. Click Main and Process, and then select Deactivate next to Bias Mode Activation. This will clear the fault.
  - h. Note any excessive build up around the cover plate or crucible and report it to staff. Staff will clean the tool if necessary.
  - i. Pump down the Dep Chamber. Click System, Vacuum System, Dep Chamber, Pump Down, and Start. Wait for the system to reach base pressure. This takes about 2 hours.
- 7. Load samples
  - **a.** Click System, Vacuum System, and Load Lock. Click Vent and then Start. The Load Lock takes approximately 5 minutes to vent.
  - b. When the load lock is done pumping remove the substrate holder and inspect. If there is flaking then scrape or vacuum the holder.



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- c. Prepare samples. Load your sample onto the substrate holder. You can affix your samples using screws, clips, or with vacuum rated Kapton tape. Make sure all screw holes are covered with tape or with screws. If they are not covered, deposition material can clog the threads, or worse, deposition material can get on the heater.
- d. Open the load lock lid and load the sample holder into the load lock. Make sure the open end of the "C" is facing into the chamber and that the notch on the holder is properly aligned.
- e. Close the load lock lid.
- f. From the "Load Lock" screen, select Pump Down and then Start. Wait for the load lock to reach base pressure, 2e-5 Torr. This should take about 15 minutes.
- g. Click Main and then Process. On the lower right of the screen, select from the dropdown menu "Transfer to Dep" and then click Load Recipe. Verify in the upper left next to Recipe that "Transfer to Dep" is listed. During a Transfer to Dep process, the Variable Angle Deposition (VAD) stage should tilt counterclockwise immediately. If it does not, stop the process.
- h. Click Start. Watch the wafer as it is loaded into the deposition chamber and be ready to hit the big red Stop button if something does not look right.
- 8. Deposit
  - a. From the "Load" dropdown menu, select "Browse...", navigate to the desired folder, and select your recipe. Click "Load Recipe." Verify that the recipe loaded.
  - b. Verify that your wafer loaded properly. Depositing without the sample holder in place can damage the tool because deposition material will get on the substrate heater.
  - c. Check recipe. Edit the "Thickness (A)" and "Timeout (s)" in the recipe after it has loaded if you need a different thickness than the saved value. Verify that the recipe loaded correctly and that the process steps have not been edited. A good practice is to have a hard copy of the recipe parameters saved for your process.
  - d. Press "Start" and monitor the deposition. Always watch the ion beam start up and look for abnormalities, such as the plasma not striking, flickering, or going out. Watch the ebeam while the power ramps up, **make sure the beam is centered,** and verify that the correct material is in place. Periodically check the tool during long depositions to make sure that there have not been any faults and that the output power is stable. Verify that the stage rotation and tilt are as expected for your recipe. Ensure the Recipe's component section, then source's sweep select is the correct pattern number. Recheck that the touchscreen on the TELEMARK Digital Sweep display says, "Remote Off."
- 9. Remove samples from deposition chamber.
  - a. Make sure the "Substrate Temperature" in the upper right of the Process window reads below 50 C.



- b. In the "Process" window, select "Transfer from Dep" from the dropdown menu and then click "Load Recipe." Verify that "Transfer from Dep" is listed beside "Recipe" in the upper left side of the screen.
- c. Press "Start." Watch the sample unload and be prepared to hit "Stop" if anything seems awry.
- d. Under "System," "Vacuum System," and "Load Lock," verify that "Sources OK to Vent" is green, and then click "Vent" and "Start."
- e. Unload the sample holder, close the lid, and pump the load lock.

## Troubleshooting

- Chamber will not vent.
  - $\circ$  Ensure lab N<sub>2</sub> is on.
  - $\circ \quad \text{Ensure lab $N_2$ bottle has enough pressure.}$
- Recipe error.
  - Clear the error by hitting acknowledge, then run the recipe again.
- Dep Chamber pump down will not start.
  - Make sure to select "Deactivate" in Main Process Bias Mode Activation.
- Failed to reach final thickness error.
  - Make sure to update "Timeout (s)" if you edit the final thickness.
- Light will not turn on
  - Click System, Overrides, and Dep Chamber. Verify that the Chamber Light is set to Auto.
- During load lock pump down, "The Turbo Pump Speed has Dropped Unexpectedly"
  - Clear the error and try pumping down the chamber again. This is mostly likely due to the chamber not being fully vented at when starting the pump cycle. If it fails twice, put a note on the tool marking it as inoperable and email staff.
- The deposition rate fluctuates with very low power.
  - Go to System, then click Sensors. In the Sensor 2 row, click "Next crystal". The rate should steady out immediately.
- Aeres software is not up.
  - Try to find the Aeres icon in the toolbar.
  - Double click the Aeres icon on the desktop. It may say it is already running. Either way, the software should come back up.
  - As a final option, only if nothing is running, restart the computer. The Aeres software should start automatically. If not, double click the Aeres icon on the desktop.

#### Troubleshooting Load/Unload

• Analyze the chamber and see where all moving parts are (Pusher, Load Lock Gate Valve and Transfer Arm) then follow the instructions below. DO NOT DO WITHOUT LAB/ TOOL MANAGER PRESENT.\*



Message/ cases	Arm	Push Mechanism	Gate valve	Solution
"Time out"	Stuck in chamber	up	up	rehome
"Time out"	Stuck in chamber	up	down	Load lock gate up
"Time out"	Stuck under chuck holder	down	up	Go to overrides, raise pusher, and home the transfer arm.
"Waiting for IO source to trigger"	Still in Ioad lock	down	closed	Keep trying
Rehoming does not work	Stuck in chamber	up	down	Lift load lock gate, jog home manually in overrides
Pusher Hit C clamp	Stuck in chamber	down	up	press the "raise" and "cancel" buttons as fast as you can. Then raise the pusher fully and home the transfer arm.

# Version History

- 2020.1 Original document written by Andrew Lingley.
- 2020.2 Clarified section 4.f on sweep controller.
- 2021.1 Clarified venting instructions and added instructions to 7.a to ensure that screw holes are covered.



- 2021.2 Edited 4.f to include instructions on how to set sweep control back to REMOTE CONTROL and clarified step 9 heading. Added grounding step to safety and opening chamber sections. Added troubleshooting information when rate is fluctuating at low power. Added time of pump down and location of chiller.
- 2022.1 Edited order of operations in step 7 to so venting the load lock is the first sub step. Corrected typos. Added important note that you must have sample holder in place during depositions.
- 2022.2 Fixed subscripts. Fixed errors in troubleshooting section.
- 2022.3 Replaced "hearth" with "crucible" to avoid confusion. Added section to remind users to note any excessive build up around cover plate or crucible.
- 2025.1 Inserted section about troubleshooting loading and unloading process.
- 2025.2 Updated accessibility for website.