BOC Edwards Auto 306 E-beam Evaporator

Operating Instructions

This machine is to be used by authorized personnel only. For training & consultation contact:

Manager, **Greg Book**, (678) 372-4665, book@arizona.edu

1. Contact a Staff Member immediately if you observe anything unusual such as the controller and the thickness monitor being off, chamber not under vacuum, or strange and unusual noises from the vacuum pump compartment below.
   DO NOT ATTEMPT TO OPERATE THE EVAPORATOR if you have any doubts!

2. Place the “Ebeam Reserved” sign on the evaporator.

3. ENABLE Ebeam using iLabs

Loading Substrates & Pumpdown

4. Press the VENT button to vent the chamber to atmosphere. Wait until the pressure display reads (>5.0 +2 TR). Gently attempt to open the chamber door. If the door resists opening, wait an additional minute or so and try again.

NOTE: DO NOT FORCE THE DOOR OPEN UNDER ANY CIRCUMSTANCES!

5. Once door is open, press the SEAL button to terminate the chamber vent.
6. Locate the 8-pocket acrylic crucible liner holders. Refer to Figure 2. Remove the lid and remove the desired crucible liner from the holder.
7. If needed, add the desired authorized material to be evaporated into the correct crucible liner (See Table 1). Do not over fill the crucible liner. If there is too much material in the crucible it may cause a thermal short or contaminate the material in the adjacent pockets. Contact Lab Manager to obtain permission to evaporate any materials that are not listed. No un-authorized evaporations are allowed!
8. Use an IPA-soaked cleanroom wipe to clean the crucible pockets and remove the accumulated dust from previous evaporations. Locate and use cleanroom vacuum if necessary to assist with particle removal. Please ask

for assistance as needed to prevent damage to the chamber components when performing this task.

9. Place liner inside the hearth pocket. If more than one film is to be deposited, rotate hearth CLOCKWISE using external knob arranging the liners in the 4-pocket crucible according to the desired evaporation sequence.
10. Place/load substrates onto the appropriate substrate holder. There are separate work plates for different size wafers. There is also an extension piece for evaporation at lower working distance/power levels. Covering the substrate holders with aluminum foil prior to mounting the samples is highly recommended.
11. Ensure Quartz Crystal Monitor USAGE is < 500. If not, please contact staff for crystal replacement, or the thickness monitor could stop indicating the deposited thickness during the deposition run. The Crystal has expired when the Xtal 1 LED on the thickness monitor panel starts flashing and no other values are displayed.
12. Close the chamber door. Press CYCLE. This will start the chamber pumpdown process.

NOTE: Liquid N2 may be used to accelerate pumpdown to base pressure when the chamber has reached the 10^{-5} Torr region. Pour Liquid N2 into the metallic funnel located on the outside and on the left side of the evaporator chamber (Refer to Figure 3).

Evaporation

13. For best vacuum,, load samples late in the evening of the day before your scheduled deposition and allow overnight pumpdown of the chamber to achieve $<10^{-6}$ Torr.
14. When the chamber pressure reaches the mid 10^{-6} Torr (5.0 -6 TR) range you can press the SEAL key followed by the PROCESS key on the Auto 306 Controller panel. The vacuum interlock LED on the EB3 source panel should light up.
15. Locate the FTM7 Film Thickness Monitor and select the appropriate layer for the metal you wish to deposit (see Table 1). To set the desired thickness press the DATA button until the TERMINATE light is illuminated. Press the green UP or DOWN arrow keys to set the desired thickness. Continue pressing the DATA button until the RATE light is illuminated.
16. Verify the FTM7 density and z-value settings for the source materials of interest using Table 1. Values can be adjusted higher or lower using the green UP or DOWN arrow keys.
17. Turn on the Sweep Control & use the X-Axis and Y-Axis control knobs located on the separate control box on the top to ensure the beam is centered inside the liner. X-Axis is forward and backwards from the operator and the Y-axis runs to left and right of the operator. You can sweep or oscillate the beam inside the liner for a more uniform melt, especially for materials that sublime.

18. On the EB3 Source Control panel ensure that the CURRENT knob is set to the minimum. Press in the HIGH VOLTAGE ON/OFF button. Press in the GUN button and make sure the high voltage and ebeam current displays turn on. After 10-15seconds the high voltage display should read a value between 4.7 and 4.9 kV.
19. Verify that the REMOTE and the SS1 buttons are pressed in on the shutter control panel.
20. On the EB3 Source Control panel, increase the current slowly by rotating the CURRENT knob clockwise to 10-15mA if practical based on Table 2 data. Let the metal and crucible stay (soak) at this setting for a few minutes or more. The metal inside the liner should start glowing. Typically, the chamber pressure will initially rise due to outgassing from the liner and its contents but then the pressure will drop back to a baseline. It is best to wait for pressure to baseline.
21. As necessary and with lots of care, slowly and slightly rotate the pocket either clockwise or counter-clockwise to make sure the pocket/liner are lined up with the beam and the opening of top shield on the hearth.

NOTE: Materials such as Bismuth (Bi),Tellurium (Te), Quartz (SiO2) start evaporating below 10mA at 4.8kV beam setting.

22. Increase the current in increments of 4-5mA and soak periods of 4-5 minutes until a desired deposition rate appears on the FTM7 monitor. Use Table 2 as a guide.
23. Press the RUN button on the FTM7 panel to open the shutter and begin measuring the deposited film thickness on your samples. Make sure that the green LED under SS1 on the SHUTTER CONTROL panel is lit.
24. The shutter will close automatically when the desired thickness is reached. Operator MUST REMAIN in the cleanroom until the deposition is complete. If you leave the area you risk evaporating all the source material and damaging hearth and crucible.

NOTE: Although the shutter will close automatically at the set point, the evaporation will not stop until the operator lowers and turns off the current.

25. Slowly reduce the current by turning the CURRENT knob counter- clockwise around 5-10mA per minute, back to zero.
26. Ensure the CURRENT knob is at the minimum setting. Allow the crucible to cool until it is no longer giving off a glow as you look through the viewport.
27. Using the turn knob change to a different liner position clockwise and repeat ramp and soak process starting at step 12.
28. If you are done with evaporation, then first depress the GUN and then the HIGH VOLTAGE ON/OFF buttons, in that order, to turn power supply OFF.
29. Turn off Sweep Control.
30. On the Main Controller panel press the SEAL button to isolate the high vacuum pump.

31. Press the VENT button to bring the chamber to atmosphere. Wait until the pressure display reads (>5.0 +2 TR). Gently attempt to open the door. If the door resists opening, give the chamber a few minutes to vent and the door will not offer resistance. Never force the chamber door open
32. Press SEAL to stop the vent N2 once the chamber door opens.
33. Remove sample holder.
34. Remove the crucible liners and place them back in the acrylic liner holder seen in Figure 2.
35. Very carefully and while taking care not to damage any chamber components, use a vacuum cleaner to remove any metal flakes and debris from the bottom of the chamber.
36. Remove the four coated glass slides protecting the viewport and replace with clean ones found in the supply cabinet.
37. Close the evaporator door and press the CYCLE button to pump down the system under for the next user.

Table 1 – Allowable/Authorized Evaporation Material & Relevant Properties

Metal	Liner Material	Layer	Density ($g.cm^{-3}$)	z-value
Aluminum (Al)	(Contact Staff)	1	2.70	8.17
Titanium (Ti)	Intermetallic	2	4.50	14.05
Copper (Cu)	Graphite	3	8.93	20.20
Chromium (Cr)	Graphite	4	7.20	28.94
Gold (Au)	Graphite	5	19.3	23.17
Platinum (Pt)	Graphite	6	21.4	36.06
Bismuth (Bi) **	Graphite	7	9.80	8.1
Nickel (Ni)	Intermetallic	8	8.91	26.66
Tellurium (Te) **	Intermetallic	9	6.25	9.3
Silver (Ag)	Graphite	10	10.5	16.68
Germanium (Ge)	Graphite	(11)	5.35	17.1
Quartz (SiO2)	Graphite	(11)	2.2	8.3
Al-Zn-O	Graphite	(11)	5.58	15.99

** Both Bismuth & Tellurium require extensive preparation. Only MNFC staff are allowed to evaporate these metals. Handling of Tellurium requires respiratory protection equipment. You must contact the Staff Engineer to deposit any material not listed.

Table 2 – Typical Evaporation Behavior in the MNFC Auto 306 E-beam Evaporation System.

Deposition rates vary depending on volume of material, beam conditions, etc.)

Metal	Pole Piece Width (mm)	Voltage (kV)	Current (mA)	Source-to-Substrate Distance (cm)	Tooling Factor
Bismuth (Bi)	10.5	4.5	9	28.6	0.5
Bismuth (Bi)	8	4.81	6	13.3 (extension)	1.9
Chromium (Cr)	8	4.5	47	28.6	0.5
Copper (Cu)	8	4.5	50	28.6	0.5
Germanium (Ge)	8	4.8	53	28.6	0.5
Gold (Au)	8	4.81	55	13.3 (extension)	1.9
Gold (Au)	8	4.5	75	28.6	0.5
Gold (Au)	9.5	4.5	82	28.6	0.5
Nickel (Ni)	8	4.81	30	28.6	0.5
Nickel (Ni)	8	4.81	42	13.3 (extension)	1.9
Platinum (Pt)	9.5	4.5	290	28.6	0.5
Platinum (Pt)	8	4.82	165	13.3 (extension)	1.9
Silver (Ag)	8	4.81	85	13.3 (extension)	1.9
Tellurium (Te)	9.5	4.45	2	28.6	0.5
Titanium (Ti)	8	4.5	72	28.6	0.5
Quartz (SiO2)	8	4.81	<10mA	13.3	1.9

Figure 1 - Evaporation Behavior of Titanium at 4.5kV (8mm pole piece)

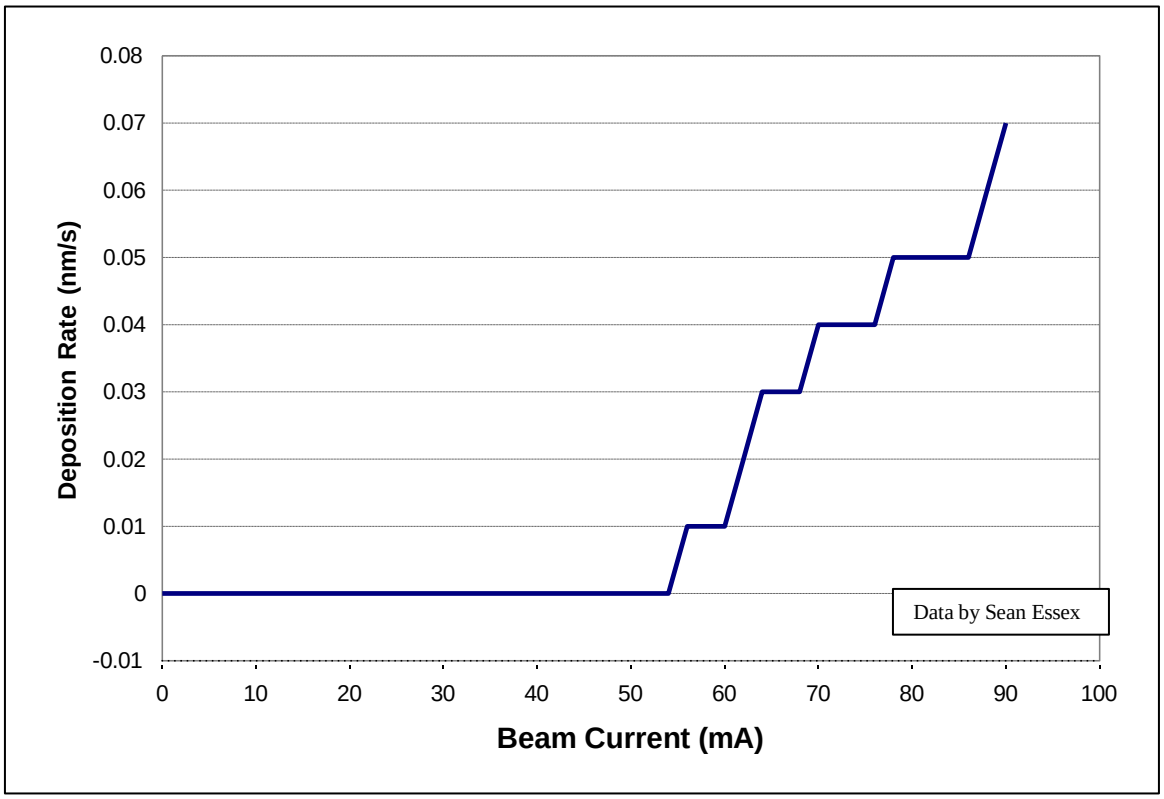


Figure 2 – Acrylic Crucible Liner Holder for common Metals

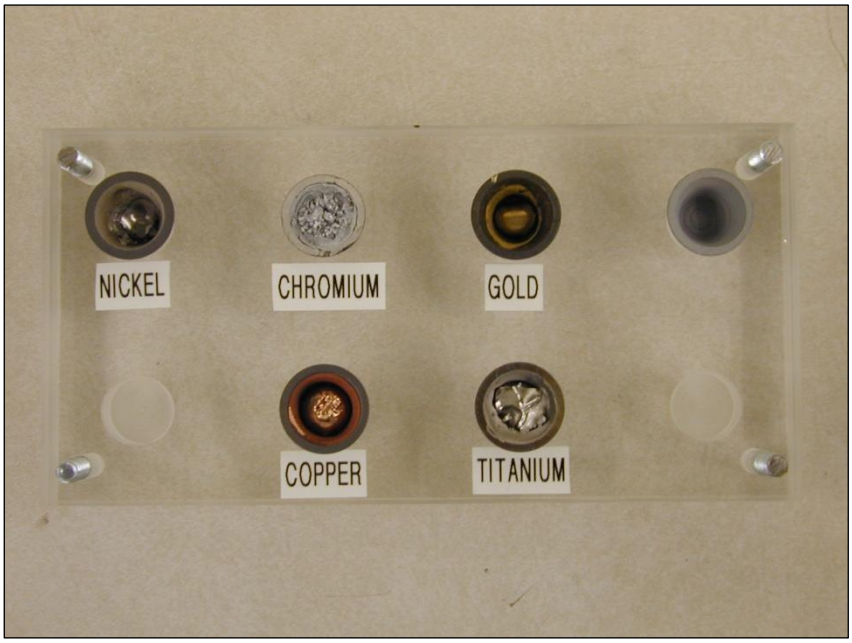
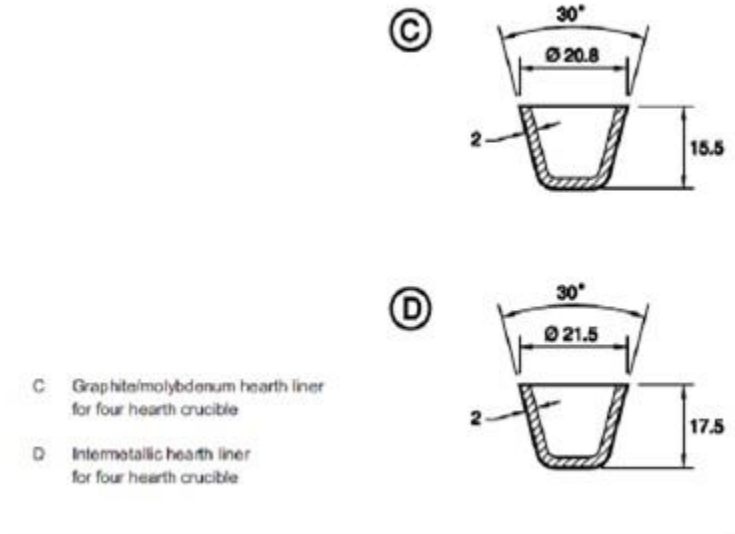


Figure 3 – Liquid Nitrogen fill funnel on the side of the chamber

2cc Crucible Liner Dimensions



Reference Position for the Quartz Crystal Monitor (Adjustment by STAFF ONLY)

Ensure center of detector head is in the same y-plane as the center of the pocket
Z (vertical distance from detector head to z-plane of the hearth) = 4”
X (horizontal distance from the center of pocket to x-plane of the detector head) = 4”

Process Consumables

- Liners (Graphite, Intermetallic): 2cc, Super Conductor Materials Inc.
- Copper: Kurt J. Lesker, Pellets 1/8”x1/8”, 99.99%, EVMCU40EXEB or CERAC Inc., 3mmx3mm pellets, 99.99%, C-2073
- Gold: Kurt J. Lesker, <4mm pieces, 99.99% EVMAU40SHOT
- Bismuth: Kurt J. Lesker, 2-4mm pieces, 99.999%, EVMBI2-4MMB
- Chromium: Kurt J. Lesker,0.8-6.0mm, 99.95%, EVMCR35D
- Titanium: CERAC Inc., 3mmx3mm pellets, 99.8%, T-2069
- Germanium: Alfa Aesar, 2mm & down, 99.999%, stock#43986