

# Kurt J. Lesker E-gun/Thermal Evaporator Instructions

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# 1. Overview of the Kurt J Lesker Evaporator

- ! If you evaporate non-approved metals in this tool, your usage privileges will be suspended.
- ! If you are found using this system before a staff member responsible for the tool has formally trained you, your usage privileges will be suspended.

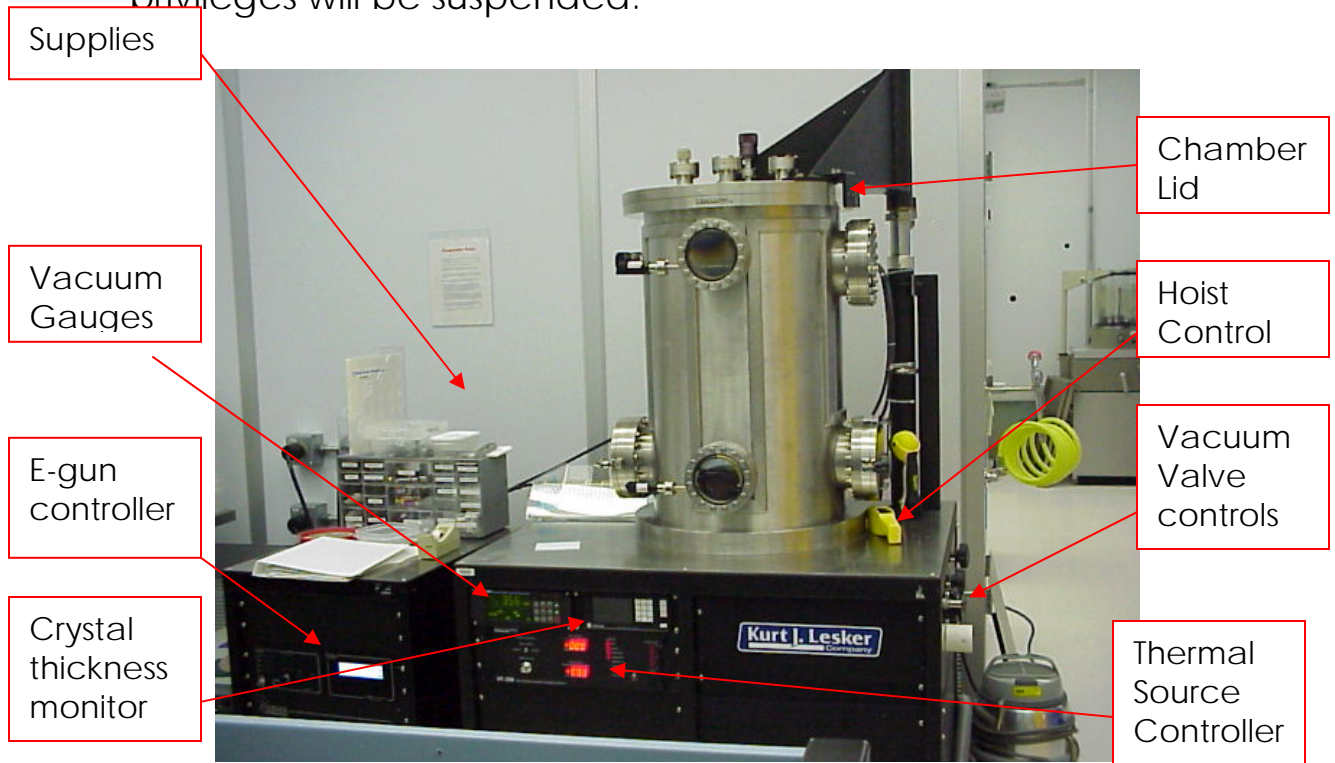


Figure 1-1: System Overview

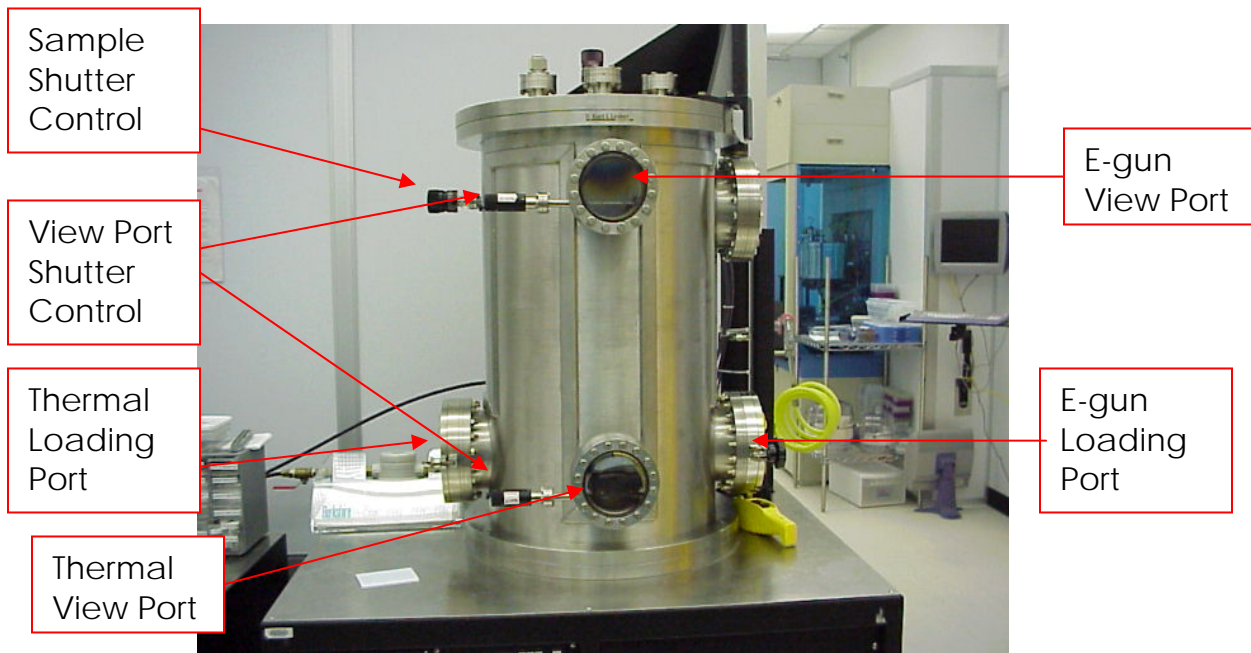


Figure 1-2: Outer Chamber View

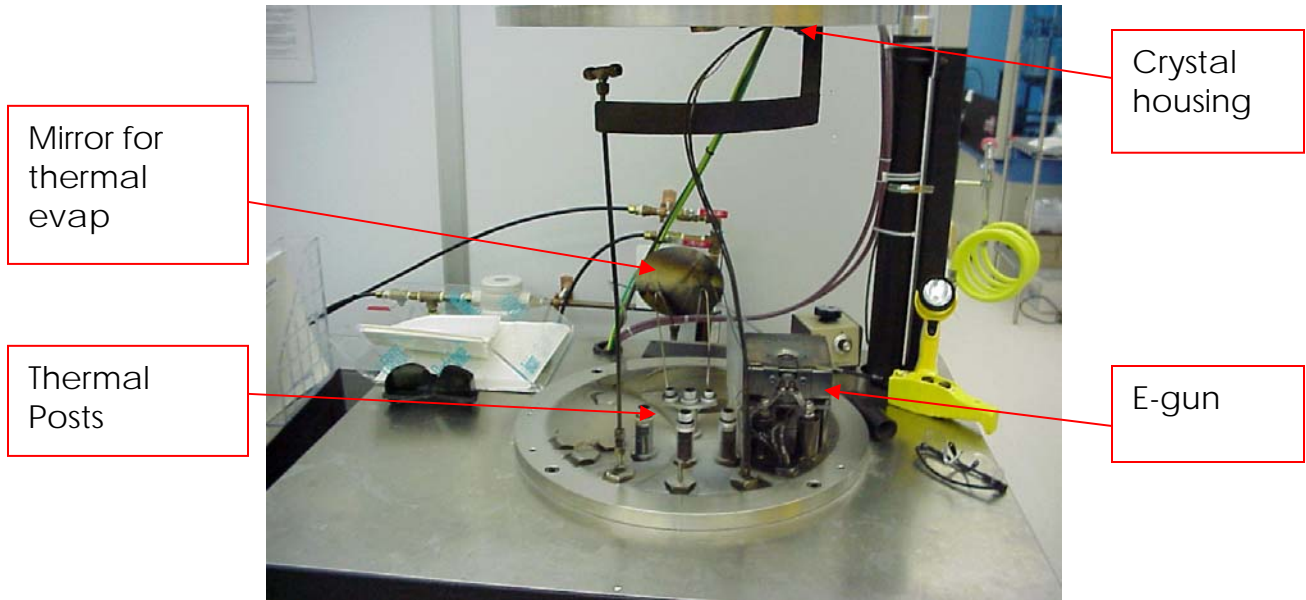


Figure 1-3: Vacuum Chamber Interior

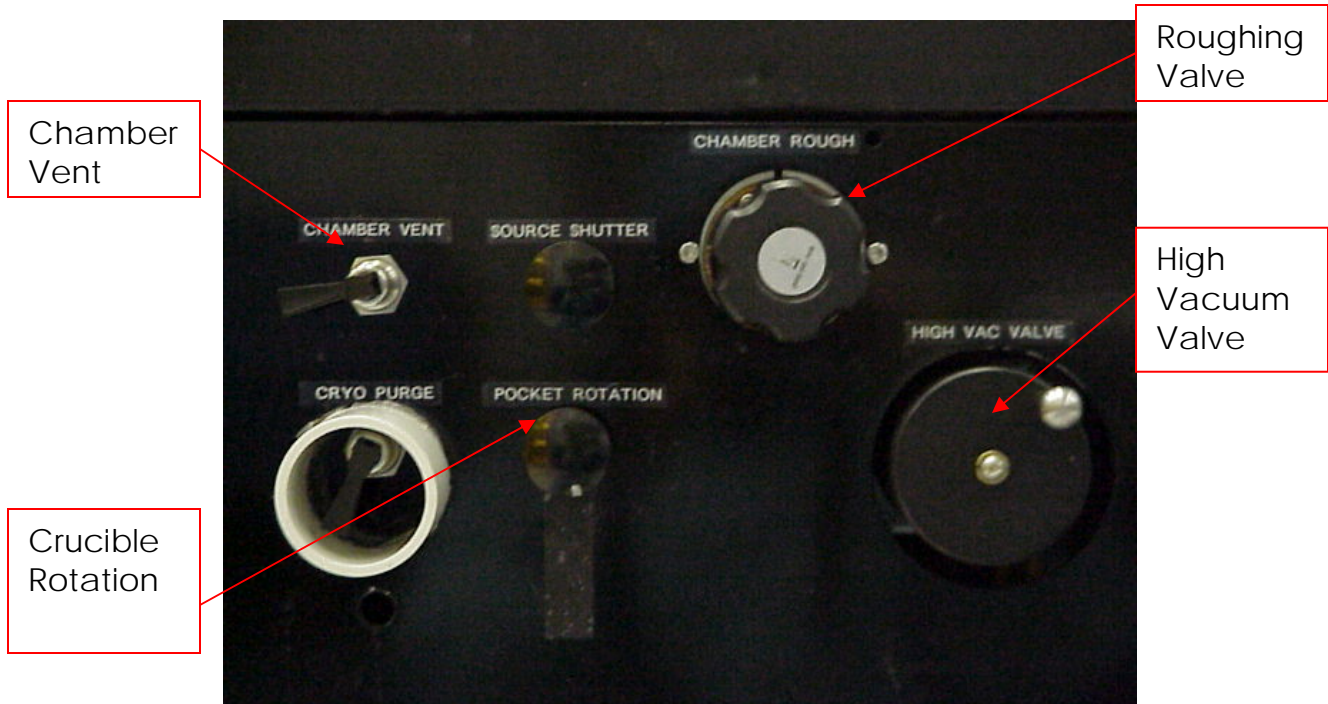


Figure 1-4: Vacuum Controls

## 2. Using The Evaporator

The evaporation process has 8 main steps:

1. Checking the system State
2. Venting the Chamber
3. Loading Metal and Samples
4. Evacuating the Chamber
5. Evaporating
6. Venting the Chamber
7. Unloading Metal and Samples
8. Evacuating the Chamber

These steps are described in detail below on the following pages.

### 2.1. Checking the Evaporator

When you first arrive at the system it should be in the following state:

1. Have both Thermal and e-gun stations turned off (figure 1-1).
2. Be in the high vacuum state  $10E-6$  to  $10E-7$ , with the Ion gauge on (figure 2-1).  
Unless previous user just finished his work.

If the previous user did not leave the system in the above condition, please send a trouble call through the Portal system



Fig 2-1: Ion Gauge ON



Fig 2-2 Ion Gauge OFF

## 2.2. Venting the Chamber

VENTING – (ONLY one valve is opened at a time, **NEVER** open more than one valve.)

1. Turn off the ion vacuum gauge. Press the ION bottom once. See Figures 2-1 and 2-2.
2. CLOSE the high vacuum valve by rotating the knob clockwise until you feel it close with some resistance. See figures 2-3 and 2-4.

**CHECK:** The handle should be in the 3 o'clock position.

**WARNING:** If the high Vacuum is not completely closed you will dump the cryo-pump. Make sure the valve is completely closed.



Figure 2-1: High Vacuum Valve Fully Open



Figure 2-2: High Vacuum Valve Completely Closed

3. OPEN the N2 chamber vent toggle valve by pulling it straight out. See Figure 2-5. See figure 2-3. On this you components such as Source Shutter and Cryo Purge are not being used presently.

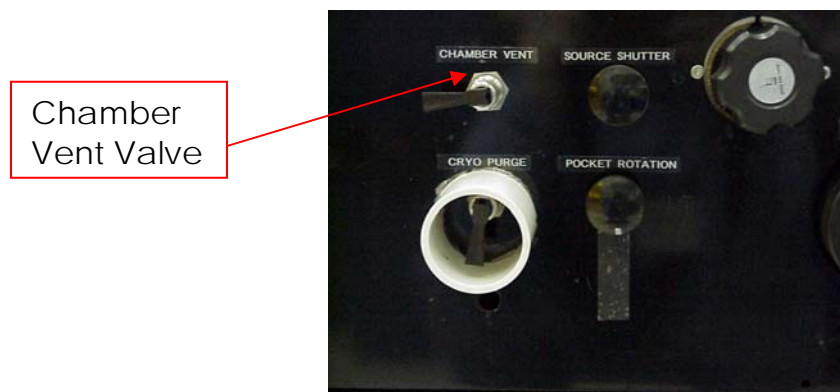


Figure 2-3: Chamber Vent Valve

4. Loosen the access doors so they open when the system comes up to atmosphere (figure 1-2).

5. The system is vented when the sample access door's open due to positive pressure inside the vacuum chamber.

## 2.3. Loading Sources and Samples

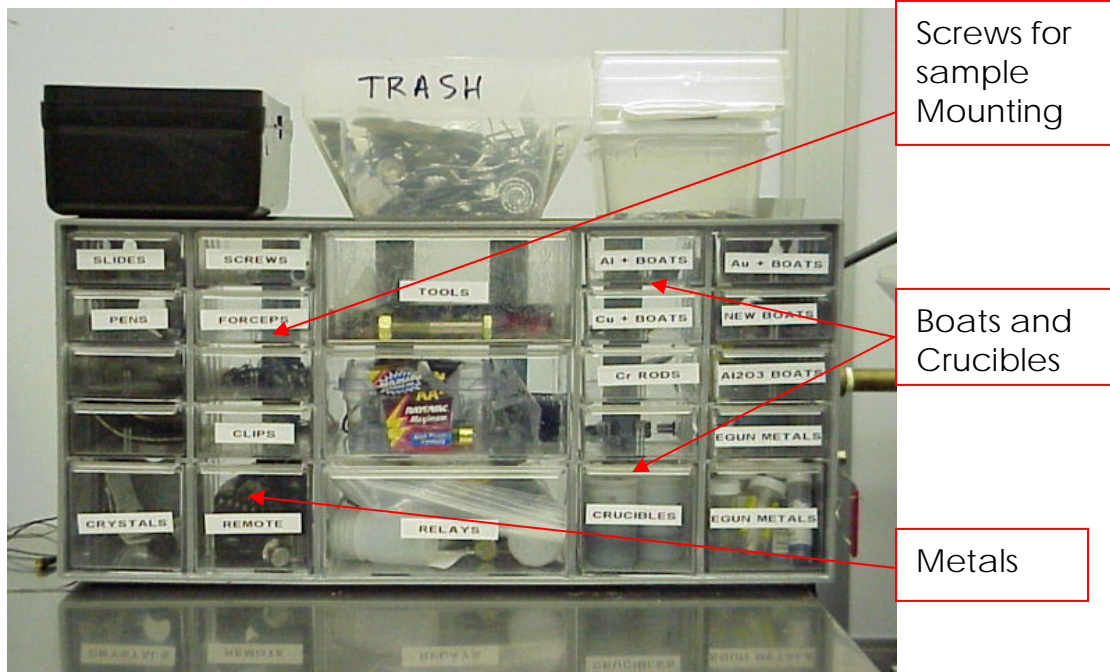


Figure 2-4: Supplies, metals and sample holders

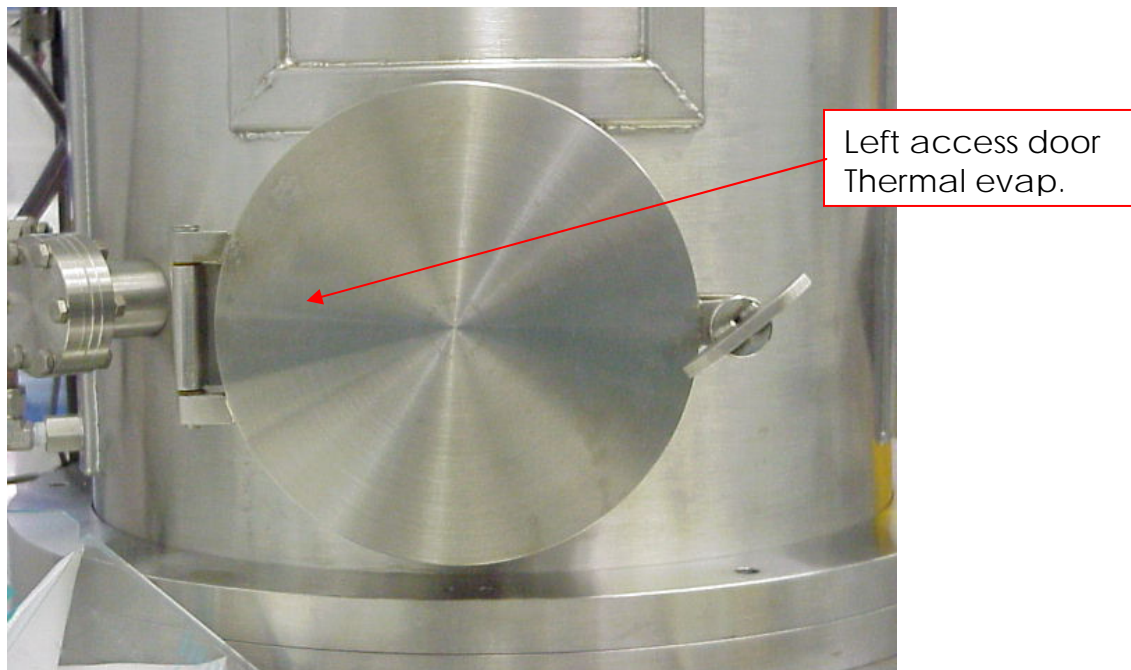
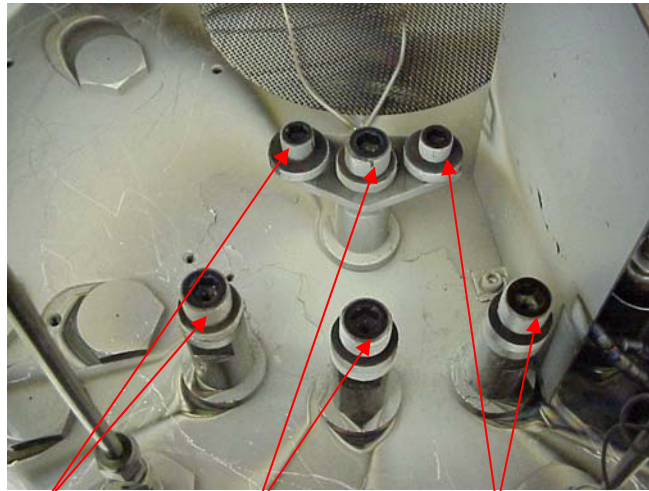


Figure 2-5: Access Port

### 2.3.1. Loading Thermal Sources

If you are using the thermal evaporation sources, Loading is from the left side access door to load the boats and metal.



Post 1

Post 2

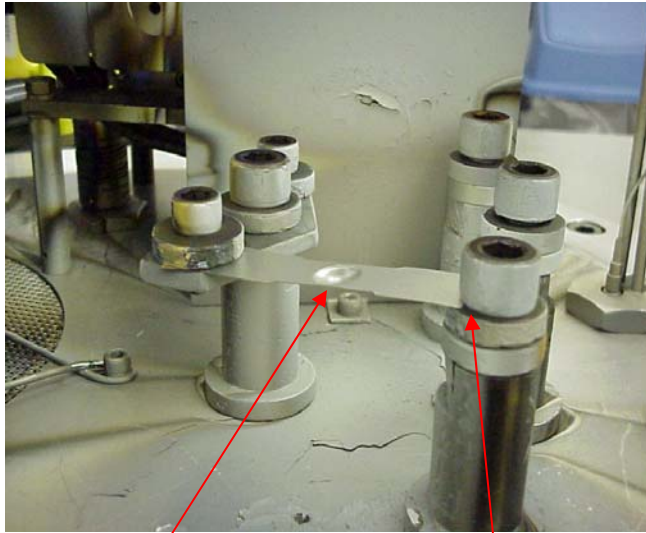
Post 3

**Figure 2-6: Thermal Posts top view**



**Figure 2-7: Thermal Posts left side view**

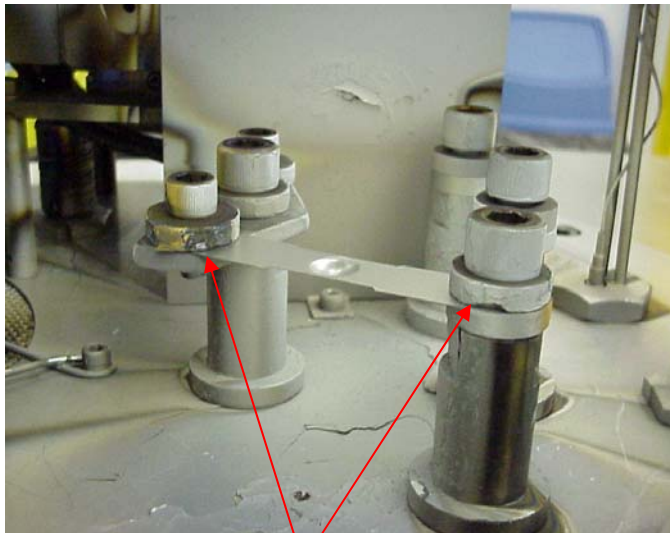
1. Place the thermal boats under the washers and finger tighten the bolts snugly, so as not to place torque on them. Once heated up they become brittle and may break prematurely if tightened too much. **CHECK** that the rear middle electrode screw is tight. **CHECK** that the thermal boats are underneath the washers. See figures 2-10 and 2-11.



Place metal  
here

**Boat NOT  
between washers**

**Figure 2-8: Thermal Boat INCORRECTLY loaded**



Boat is between  
washers

**Figure 2-9: Thermal Boat CORRECTLY loaded**

2. Place the metal pellets in the dimple of the boat(s). Note how many pellets others have used for similar metal and thickness. Record how many pellets you use and what thickness you deposit in the logbook.



Figure 2-10: Thermal “dimple” boat

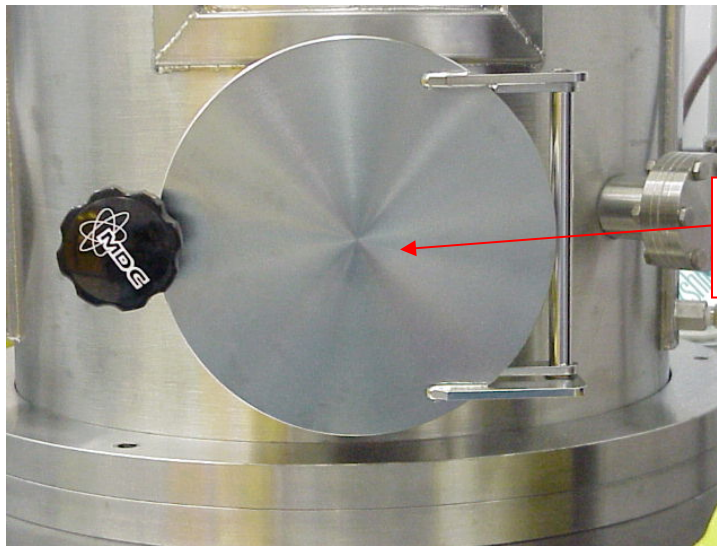
Table 1: Thermal boat setup

<b>Metal</b>	<b>Expected film thickness / Pellet</b>	<b>MAX allowed Pellets</b>
Al	150A / Pellet	8
Ag	150A / Pellet	9
Au	150A / Pellet	9
Cu	150A / Pellet	9

3. Check the O-ring(s) of the access doors for particulates. Clean with IPA on a clean wiper if necessary. If the chamber has a large amount of loose metal flakes. Use the vacuum located aside of the evaporator or in the togging room to vacuum them up. Be conscious of the metal boats, pellets and crucibles, don't accidentally vacuum them up.

### **2.3.2. Loading the e-gun Evap. Source Crucibles**

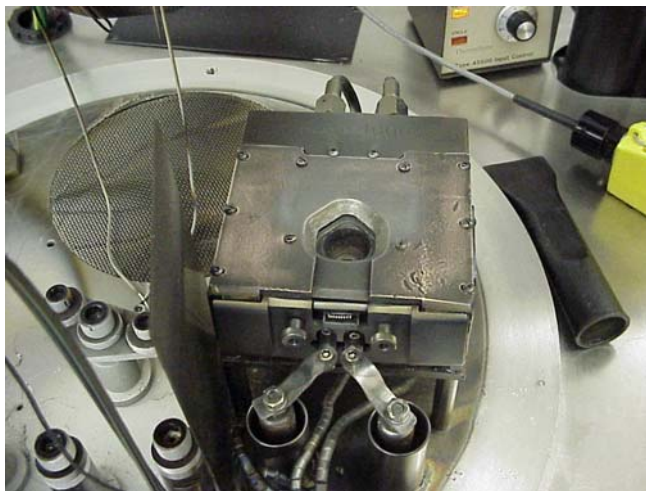
If you are using the e-gun evaporation source (Cr, Au/Ge, Mo, Ni, Pd, Pt, Ta, Ti, etc.) you can access the crucible holder via the right side access door (figure 2-13).



Right access door  
e-gun evap.

**Figure 2-11: E-gun Access Door**

1. Check in the supplies box for crucibles and metals. Place the desired crucible into the pocket tray of the E-gun Evap. Source. See figure 2-14.



**Figure 2-12: E-gun Source pocket front view**

2. Refer to Metal Info. Sheet to determine if you need to add pellets to the crucible. For some metals which sublime it is OK to add material to full level for low temperature materials topping it will result in metal flowing out of crucible.
3. During one session you can e-gun up to 4 metals. Load desired types of crucible to source pockets. Select source pockets by rotating the Crucible Rotation knob (figure 1-4). The white mark on the knob will help you define position of the pocket. One CW revolution moves the carousel up by one pocket in CCW direction.
4. **Note:** Make a note of the position of the crucibles and which way to turn the rotational knob, before you rough pump the system.

### 2.3.3. Sample Loading

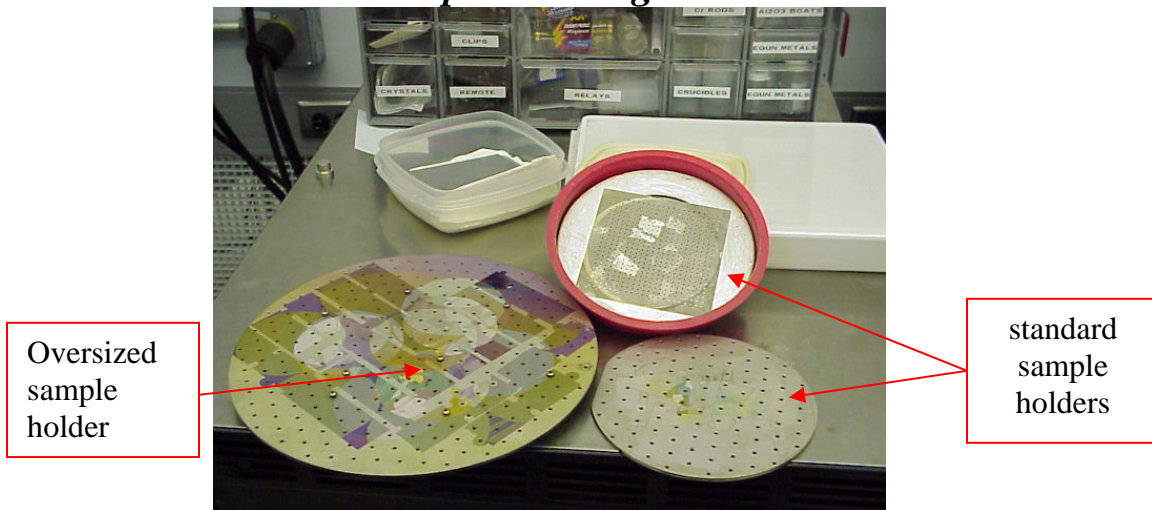


Figure 2-13: Sample holders

1. Position your sample(s) on one of the sample holder's and secure them with washers and screws or with Kapton tape. If no tape is available ask for more from a staff member. (figure 2-15).
2. Raise the lid (figure 2-16).
3. **CHECK:** Make sure the shutter is not so high that it presses against your sample.
4. Load the sample holder onto the sample stage (figures 2-17 and 2-18).



Lift lid only when chamber is at atmosphere

Lift chamber lid with hoist

**Figure 2-14: Chamber Lid Open**



**Figure 2-15: Empty Sample stage**



**Figure 2-16: Sample state with 6" small parts holder loaded.**

## **2.4. Evacuating the Chamber**

**WARNING:** ONLY one valve is opened at a time. NEVER open more than one valve.

1. **CLOSE** the *chamber vent* valve.
2. Close all chamber ports. (Left and right access door, and the chamber lid)

**Rough the chamber below 200 mTorr**



**Figure 2-17: Roughing Vacuum Gauge**

3. Open the Roughing Valve by turning it counterclockwise until it stops and is fully open.

**CHECK:** You will not be able to open the door once the vacuum has been established. If the door can be opened after about 10 seconds of pumping, there is a leak. Usually the lid is slightly ajar or you have left one of the access doors open. Close the *roughing valve* and re-position the *chamber lid*. Try pumping the system down again.



Open/Close  
chamber  
Rough

**Figure 2-18: Vacuum Roughing Valve**

4. Monitor the roughing gauge until it reaches about 200mtorr ( $2.00 \times 10^{-1}$ ) within 5-10 minutes. Then CLOSE the roughing valve turning it clockwise until closed.
5. OPEN the Main High Vac Valve turning it counterclockwise until it's completely open and stops.



Figure 2-19: High vacuum valve fully open

6. After opening Hi Vac valve wait a minute or two, and then turn on the *ion vacuum gauge* by pressing the ION button switch once.
7. You should reach the low  $10E-6$  Torr range in about 30 minutes.
8. Go to either section **2.5.1** “Evaporating Using The E-gun Source” or section **2.5.2** “Evaporating Using the Thermal Source” section to evaporate.

## 2.5. Evaporating

**NOTE:** You should wait until the system pumps down to the low  $10E-6$  Torr range for most evaporations.

**WARNING:** Most metals will oxidize quickly at  $10E-5$  Torr or higher.

## 2.5.1. Evaporating using the e-gun Source



Figure 2-19: E-gun controller

1. Turn on the crystal Thickness Monitor if not already on.

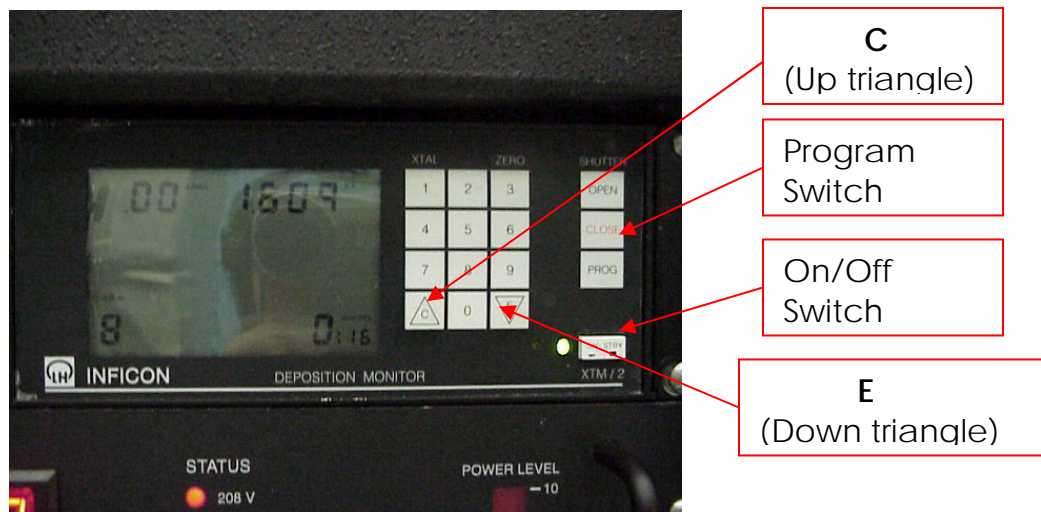


Figure 2-20: Figure: 28 Crystal thickness monitor

2. Program the Crystal Thickness Monitor

- Press **Prog**
- Press **C** (Up triangle) until *film #* is active
- Enter **number** of the metal you will evaporate (from the “metals info” sheet)
- Press **E** (Down Triangle) until the *tooling* is active. Enter the correct tooling factor base on:
  - Thermal Evaporation: 63.6
  - E-Gun Evaporation: 61.0
- Press **Prog**

Note: Pressing “Zero” will reset the deposition readouts and start the timer at the lower right of the display. This is convenient for timing the “SOAK” steps.

3. Double check that the shutter is up protecting the substrate from being deposited on.
4. Turn on *10kV Evap CVS 6 Power Supply Breaker*. (refer to figure 2-24)
5. Turn on *EVAP Source Control*. See figure 2-26.

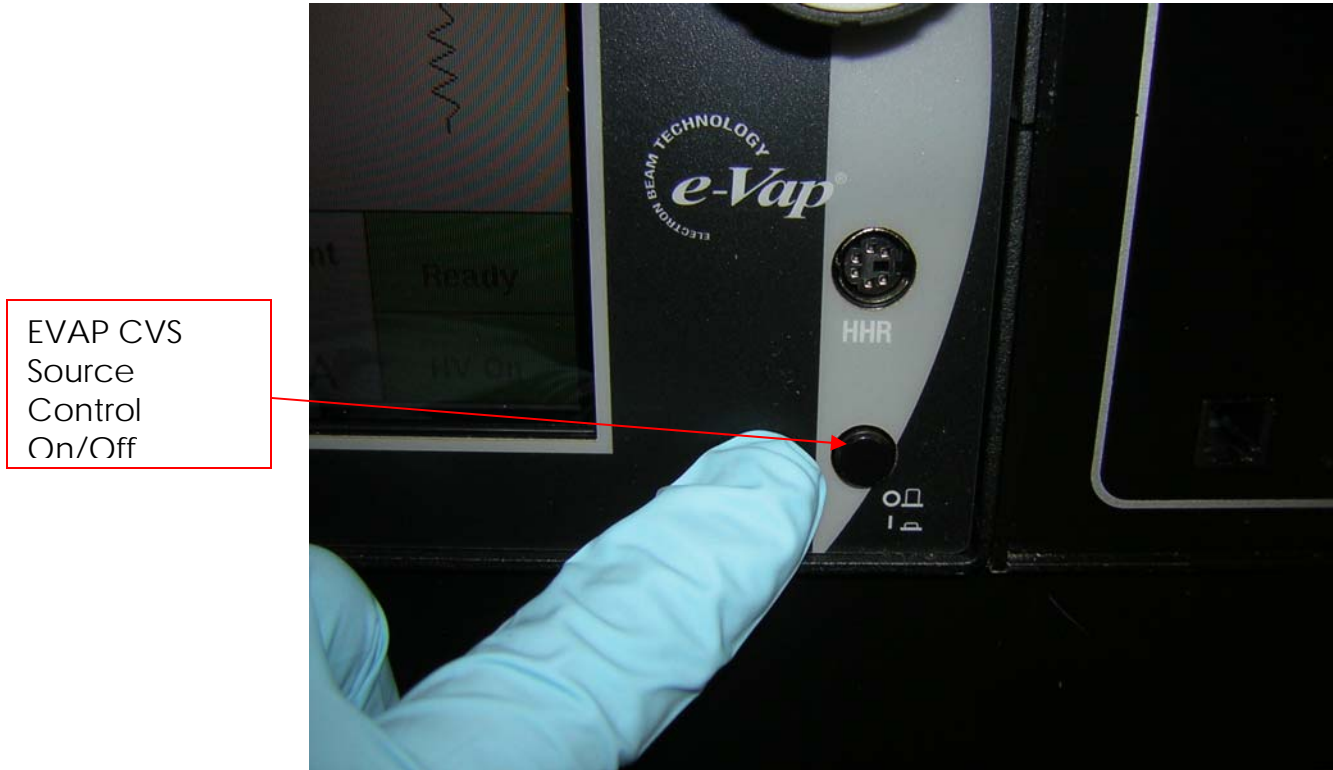
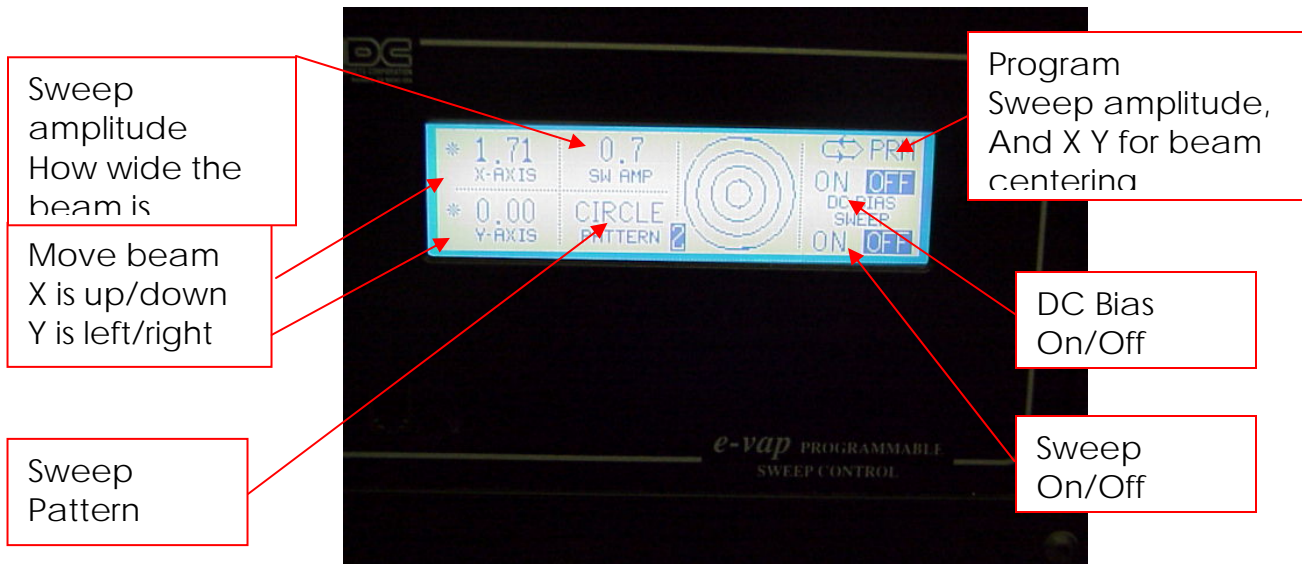



Figure 2-21: E-gun Source Controller ON/OFF

6. Check that all 5 of the interlock lights are GREEN on the *EVAP Source Control* are on by pressing the “**Fil Time Hours**” button. If not, stop and find a staff member to assist you. When finished press the “**MAIN SCREEN**” button.
7. Turn on the SWEEP on the *E-gun Programmable Sweep Controller*.(If the unit indicates “**SWEEP ERROR**” at any time notify a staff member.) See figure 2-27.



**Figure 2-22: E-gun Programmable Sweep Controller**

8. Turn on the **DC BIAS** on the E-gun Programmable Sweep Controller. See figure 2-27.
9. Program the **Sweep Amplitude** on the E-gun Programmable Sweep Controller:
  - Touch **PRM** on the *E-gun Programmable Sweep Controller*. If **PRM** is not displayed press the  symbol and then press the **PRM**.
  - Always use pattern 1 Circle.
  - Touch the **SW AMP**.
  - Touch the **UP ARROW** or **DOWN ARROW** so that the correct sweep amplitude amps from the “E-Gun Metals Information” sheet. **NOTE:** There are different sweeps depending on the metal *AND type of crucible*.
  - Touch **PRM**
10. Press the white high voltage (HV) button on the *10kV Evap CVS 6 Power Supply*. The voltage should ramp up to between 8.20kV and 8.75kV. See figure 2-24  
**WARNING:** DO NOT ADJUST Voltage while doing a run – It will change the beam centering position. Record any discrepancies.
11. Record the base pressure in the log book
12. Check that **EMIS SET PT** is set to 0 by pressing “**EDIT EMISSION**” button. This button may also read “**Save Emission**” - if it does you are already in edit mode. After pressing the button when it reads “**Save Emission**” you will not be able to change the emission.
13. Turn on the *emission/filament* by pressing the “**EMISSION IS OFF**” button on the *Evap Source Control*. When *emission/filament* is on this button will read “**EMISSION IS ON**” and will be green.
14. Wait up to 30 seconds for the filament to light. Verify through the viewport.
15. Slowly turn the *Filament Adjust Knob* to 10 mA on “EMIS SET PT”, not FIL CURRENT, OR EMISSION CURRENT.

16. You can monitor the filament and crucible by viewing their reflections in the mirror mounted to the underside of the shutter (set it to approximately 240 marker). Look up through the top view port.
17. Put on dark safety glasses. Check that the **entire filament** is glowing. If only a part of the filament is glowing (which would mean part of it is shorted to the shield), abort the run and notify **any available staff**.
18. Make sure the electron beam is in the center of the crucible when doing a run. If it is not, find a staff member to help you center the spot.
19. **WARNING:** DO not under any circumstances keep continue an evaporation if the beam is not centered. You could ruin the crucible and possibly worse. (The beam would start to heat up the crucible pocket and drill in to waterlines!)  
Seek staff help!
20. Following the “E-Gun Metals Information” sheet turn up the **EMIS SET PT slowly** to the first “SOAK” amperage. Monitor the evaporation rate after each soak. If you see a rate greater than 0.5 Angstrom/sec before you reach the final soak, the remaining soaks may be skipped. **Never exceed the MAX deposition rate for the metal.**
21. After you get a steady evaporation rate (1 or 2 angstroms/second) start the deposition by swinging the sample holder to the right (counter clockwise) from behind the *shutter* and zeroing the thickness monitor, ideally at the same time.

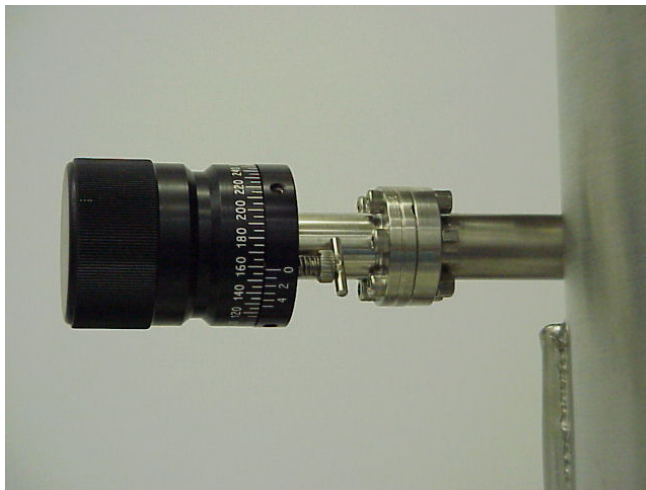


Figure 2-23: Sample shutter control knob



Figure 2-24: View of inside of chamber with the shutter in the down (dropped) position

22. If the deposition rate drops, abort the run. **Something has gone wrong with the system.** Please notify a **staff member**. You may attempt to start over with the last soak cycle. Abort if it still malfunctions.
23. Move sample behind the *shutter* when your thickness has been achieved.
24. Gradually turn down the *EMIS SET PT* to zero. Refer to the “E-gun Metals Information” sheet for information on which method to use for turning down the power.
  - (1)  $\frac{1}{2}$  **current/minute**: Turn the current down to  $\frac{1}{2}$  of its present setting every minute
  - (2) **Reverse order**: Turn the current down in the reverse order of the soaks stopping at each soak for at least 2 minutes
25. Record the number of Angstroms evaporated in the log and the Portal.
26. *If you wish to electron beam evaporate another metal rotate in another metal(see section on metal loading) and go to step 9.*
27. If done with E-gun evaporations, press “**EMISSION IS ON**” button on the *Evap Source Control*. It will then read “**EMISSION IS OFF**”
28. Turn **OFF** the **SWEEP** on the *Sweep Controller*.
29. Turn **OFF** the **DC BIAS** on the *Sweep Controller*.
30. Press the **green** RESET button on the *E-gun Power Supply*.
31. Turn OFF the *Evap Source Control*
32. Turn OFF the *10kV Evap 6 Power Supply breaker*.
33. If you wish to thermally evaporate materials, go to that section now.
34. If you are finished with all the evaporations turn off the *Crystal Thickness Monitor*.
35. **Wait at LEAST 30 minutes for the system to cool down before venting chamber.**
36. This is good for two reasons: 1) you will not oxidize your sample(s).  
2) The boat or crucible would still be hot.
37. Go the section 2.2 “**venting the chamber.**”

## 2.5.2. Evaporating Using the Thermal Source



Figure 2-25: Thermal source controller

1. Turn on the Crystal Thickness Monitor. See Figure 2-31.

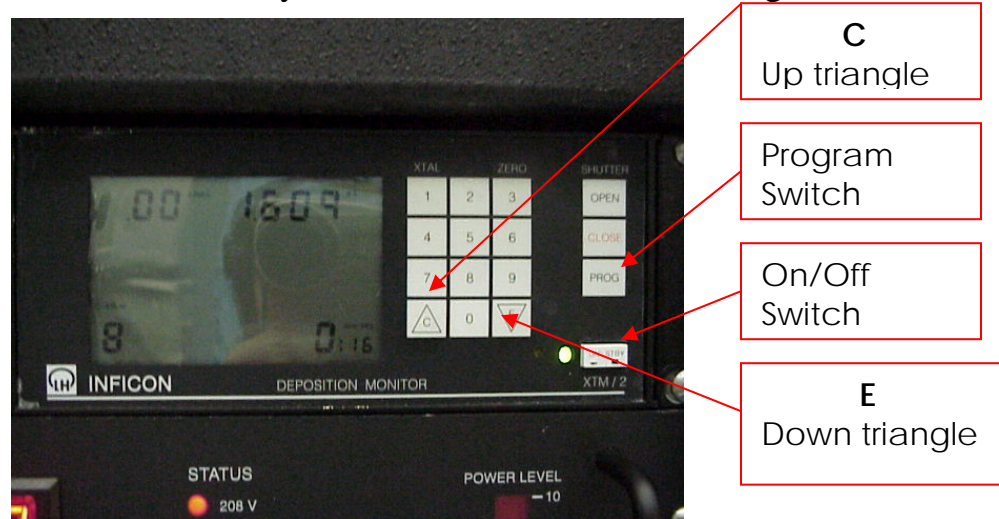


Figure 2-26: Crystal thickness monitor

2. Program the Crystal Thickness Monitor.

- Press Prog
- Press C (Up triangle) until film # is active
- Press the number of the metal you wish to evaporate (from the “metals info” sheet)
- Press E (Down Triangle) until the tooling is active. Enter the correct tooling factor base on:  
[Thermal Evaporation: 63.6](#)  
[E-Gun Evaporation: 61.0](#)
- Press Prog

3. Ensure that the shutter is closed and the sample is behind the shutter.
4. Make sure that the Power Control for the thermal source has been turned all the way counterclockwise
5. Rotate the post selector to the desired post. 1=Left Post, 2=Center Post, 3=Right Post also see loading metal section pg.



Figure 2-27: Post selector

6. Turn on the Main Power to the thermal source by pressing the toggle switch. See Figure 2-33.
7. Turn up Power Control to about 25% (5% per bar) and allow it to warm up for about 1-2 min. Then increase to 30% and wait until it glows.

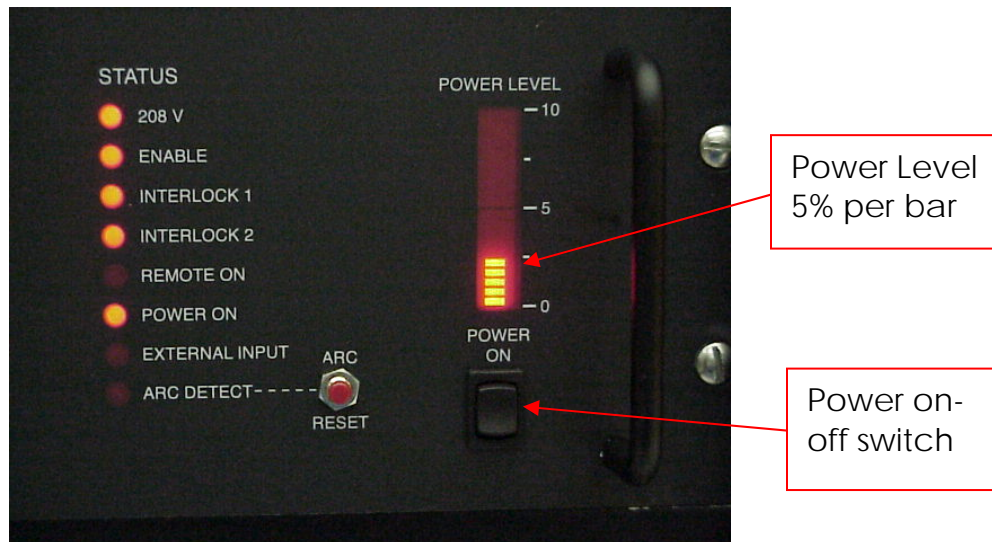


Figure 2-28: Source control power level at 25%

8. Then slowly turn up the Power Control until the metal melts, turn up the power about 10 volts rms every 1-2minutes (figure 2-30), until the desired deposition rate has been achieved. Do not exceed 75%.
9. When you feel a good rate has been achieved, lower the shutter and zero the thickness counter.
10. Close the shutter after the desired thickness has been achieved.

11. Turn the Power Control knob all the way counterclockwise
12. Turn off the Main Power toggle switch.
13. Record the number of Angstroms evaporated and the evaporation pressure in the log.
14. If you wish to thermal evaporate from another post switch to that post and go to step 2.
15. If you wish to E-gun evaporate a metal go to the section “Evaporating Using the E-gun Source”
16. Wait 30 minutes to allow the system to cool. You should wait longer than 30 minutes if you evaporated more than 1000 Angstroms.
17. Check the crystal life by pressing 1. If the percent used is greater than 15% please replace the crystal. Turn off the Crystal Thickness Monitor.
18. .Go to section 3 “Final Check List”

### **3. Final Check List**

**NOTE:** Users are responsible for cleaning up after themselves.

Vacuum the chamber interior through the access doors, as needed. Use the clean room vacuum located next to the evaporator or in the gowning area.

#### **3.1. Venting the Chamber**

Before venting, wait at least 20 minutes to let the system interior cool down. See section 2.2 to vent the chamber

#### **3.2. Unloading Metal and Samples**

1. Remove the sample holder from the system.
2. Remove your sample(s) from the sample holder.
3. Remove dispose any thermal boat and put them in their proper place (dispose of any boats that do not have gold in them).
4. Remove e-gun crucibles and put them in their containers

#### **3.3. Evacuating the Chamber**

See section 2.4 to evacuate the chamber. Please leave the system in high vacuum.

## **4. Training Check List**

- Overview of the system
- Venting system
- Loading samples
- Loading sources (including adding metal to e-gun crucibles)
- Evacuating the chamber
- Evaporating using the e-gun source (including melting in new metal)
- Evaporating using the thermal source
- Changing the thickness monitoring crystal
- Cleanup!
- Add to List on Portal

## 5. Crystal Thickness Metals Info **TOOLING FACTOR: 63.6 for Thermal 61.0 for EGUN**

Metal	Crystal	Purity %	Density	Z-Ratio	Verified Thickness	Notes
Ag	*	99.999	10.500	0.529	(1),(2)	
Al	1	99.999	2.7	1.08	(1),(2)	Wicks up crucible liner and tungsten boats
Au	2	99.99	19.3	0.381	(1),(2)	
AuGe	2	99.999	19.3	0.381	(1),(2)	88% Au, 12% Ge (Uses Au's #'s)
C	*	99.99	2.250	3.260	(2)	Sublimes, Outgases
Cr	3	99.99	7.2	0.305	(2)	Sublimes, Evaporate oxide before depositing
Co	*	99.95	8.900	.343		
Cu	*	99.999	8.93	0.437	(1),(2)	
Er	*	99.99	9.09	.74		Sublimes
Fe	*	99.999	7.860	0.349	(2)	
Ge	*	99.999	5.35	0.516	(1),(2)	
Mg	*		1.74	1.61	(1),(2)	Can use Ta2 part boat, see Joe
Mo	*	99.95	10.2	0.257	(2)	
Ni	4	99.98	8.91	0.331	(2)	
Pd	5	99.95	12.038	0.357	(2)	
Pt	6	99.99	21.4	0.245	(2)	Sparkling Metal
Si	*	99.999	2.320	0.712	(2)	
SiO <sub>2</sub>	*		2.20	1.00	(2)	
Ta	7	99.95	16.6	0.262	(2)	
Ti	8	99.995	4.5	0.628	(2)	Wicks up side of crucible liner
ZnSe	*		5.42	0.722	(1),(2)	

### Crystal Key:

\* Use metal #9 on the thickness monitor and program in the density, Z-ratio, and tooling factor.

### Verified Thickness:

- (1) Tooling factor from thermal gold evaporation. The thickness of thermally evaporated films has not been verified
- (2) Tooling factor from E-Gun nickel evaporation. The thickness of e-gun evaporated films has not been verified.
- (3) Thermal evaporation film thickness has been confirmed to be within 10%.
- (4) E-gun evaporation film thickness has been confirmed to be within 10%.

## 6. E-Gun Metals Information

Metal	Notes	Sweep (Amp)	Crucible	Soak 1 (mA/Min)	Soak 2 (mA/Min.)	Soak 3 (mA/Min.)	Soak 4 (mA/Min.)	Max Rate (A / sec)	Cool Down Rule
Al		0.5	Intermetallic	10/2	25/2	50/2	75/2	5.0	½ current / minute
Au		1.0	W	35/3	80/2	120/2	160/2	1.5	½ current / minute
Ag		0.7	VC	30/2	60/2	75/1		5.0	½ current / minute
C	2	1.4	VC	30/3	60/3	100/2	140/1	2.0	½ current / minute
Cr	2,3	1.4	VC	15/3	30/2	50/2		8.0	½ current / minute
Co	1,4	1.1	VC	25/2	40/2	60/2	80/2	2.0	Reverse Order
Cu		1.0	VC	30/3	60/2	90/2		10	½ current / minute
Er	7	0.5	VC	10/2	20/2	30/2		5.0	½ current / minute
Fe	1	1.2	VC	40/3	60/2	80/2	100/2		½ current / minute
Ge	5	1.0	VC	10/2	20/2				½ current / minute
Mg		1.0							½ current / minute
Mo	2, 4	1.0	VC	75/5	100/3	175/2	250/1		½ current / minute
Ni	1	0.6	W	35/3	80/2	140/2		1.5	½ current / minute
Pd	2, 4	1.0		45/4	65/2	75/1	85/2		½ current / minute
Pt		0.5	C	50/5	100/4	150/3	200/2		½ current / minute
Si		1.0	VC						½ current / minute
SiO <sub>2</sub>		1.4	VC	10/2	20/2	30/1	Raise as needed	5.0	½ current / minute
Ta		0.8		100/5	255/3	300/3	400/2	1.0	½ current / minute
Ti	2, 3	1.0	VC	20/5	40/3	60/2	80/1	4.0	½ current / minute
ZnSe		1.2							½ current / minute

### Notes:

1. Magnetic material: will deflect beam until material melts
2. Out-gases: chamber pressure will rise
3. Getters: chamber pressure will fall
4. Spits: small pieces of molten metal jump from crucible
5. Will form crystals in crucible
6. Rate will suddenly shoot up once the metal melts
7. Sublimes

### Crucible Lines:

Cu = Copper  
 VC = Vitreous Carbon  
 C = Carbon  
 Intermetallic = TiB<sub>2</sub> – BN alloy  
 W = Tungsten

### Thermal Boats:

W = Tungsten  
 Mo = Molybdenum