



## **Operating Procedures for Metal Evaporator I**

Metal Evaporator I is intended as a tool and a training device. Understanding the operation of this equipment should give you a basic knowledge of vacuum and e-beam evaporation techniques. Because Metal I is a training device, manual operation of the vacuum system is the default mode.

Take your time when using this equipment to avoid accidents. If you are not sure about something concerning this equipment, seek help rather than taking a risk and causing a problem. Because this is a heavily used piece of equipment, down time affects a large number of cleanroom users.

In order to become qualified in the use of Metal Evaporator I, you must first be qualified on Metal Evaporator II, completed a minimum of 10 runs on Metal Evaporator I under the supervision of a qualified user, watched the videotape about Metal Evaporator I, watched the videotape about Basic Vacuum Systems, read and understood this operating procedure, correctly answered the qualification questions and successfully performed a run on the equipment for the cleanroom manager or technician.

### **Condition of Equipment Prior to use**

The vacuum chamber should be under high vacuum with the ionization gauge off. The e-beam power supplies should be off; the voltage and current adjust knobs turned fully counterclockwise to their zero positions, and the cooling water off. The only pocket with a crucible should be #3 and that should be gold (Au).

### **Operating Procedures**

1. Once you have signed up for use and obtained the key from the nitrogen purge box to enable the e-beam power supply, inspect the condition of the chamber prior to use. If the chamber is in a neglected or unsafe state, notify the appropriate personnel as soon as possible.
2. Vent the chamber by first insuring the ionization gauge is off, and then depress the HI VAC switch to close the gate valve. The green light above the HI VAC switch should be red at this time. Wait until the operation of the gate valve is no longer audible, then depress the VENT switch so that the green light illuminates. At this point, you should hear the rush of nitrogen gas into the chamber and see the chamber pressure rise as indicated by the A Thermocouple Gauge readout on the Vacuum Controller. When the chamber pressure is greater than 1.0 torr, the readout will be 9.9 +9. This situation is due to the limited range of a thermocouple gauge ( $1.0 - 1.0 \times 10^{-4}$  torr).



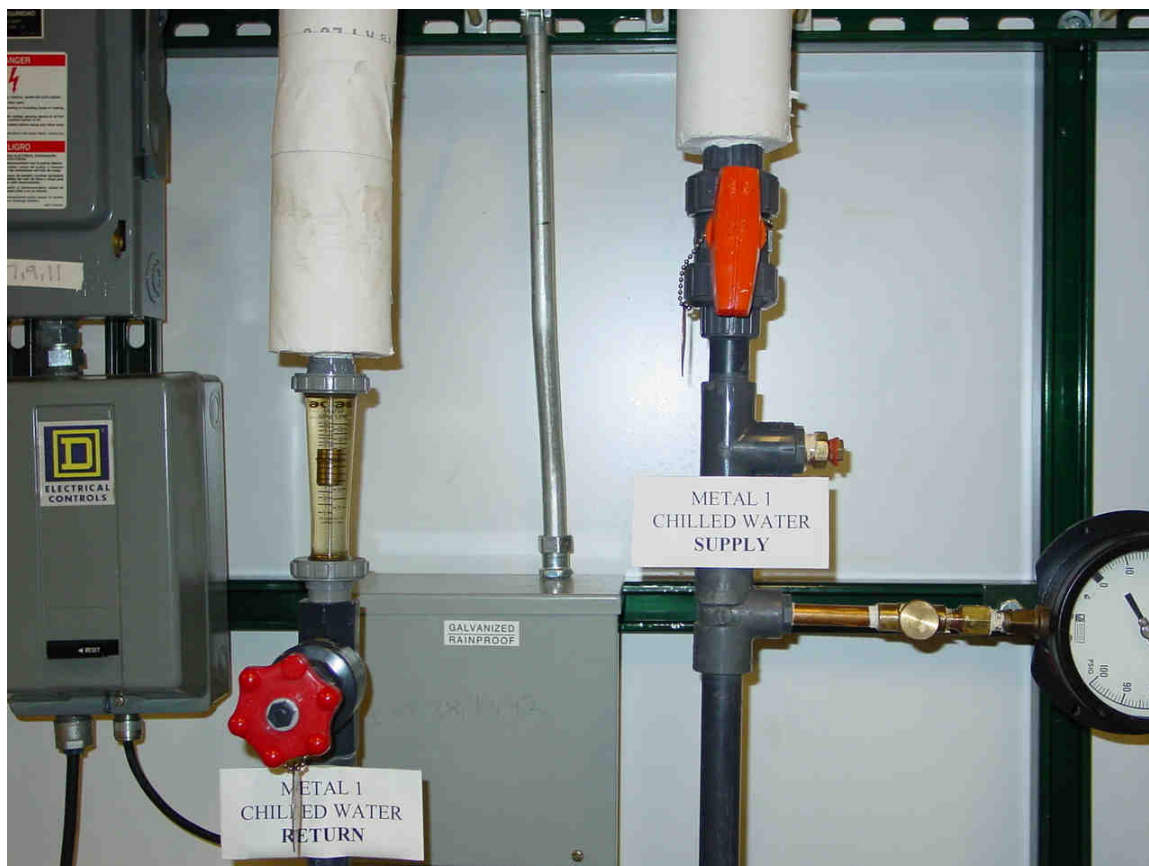
Figure 1 Vacuum Gauge Controller and Crucible Indexer



**Figure 2 Inficon Thickness Monitor, Valve Control Panel and Shutter Switch**

3. Once the chamber reaches atmospheric pressure, the front door will partially swing open and gas can be heard escaping the chamber. Depress the VENT switch to shut off the nitrogen gas. The red light should be illuminated after depressing this switch.
4. Swing the door open. Inspect your gloves for any rips and change them if there are any rips before placing your hands into the chamber. Inspect the interior of the chamber for any foreign debris. Use the vacuum cleaner to remove any debris such as flakes.
5. For each pocket that you will use to hold a crucible, you must thoroughly clean each pocket to insure good thermal contact between the crucible and the pocket. First, use a green Scotch-Brite pad and scour the entire pocket. Then use a clean cloth soaked in isopropanol to wipe the pocket clean. Inspect the pocket for cleanliness. If particles still exist in or around the pocket, use the vacuum cleaner to remove these particles. Repeat for each pocket to be utilized using the crucible indexer to rotate the hearth.
6. Insert your desired crucibles into the cleaned pockets after wiping the bottom of the crucibles with isopropanol and place the appropriate card in the designated cardholder indicating the type of metal in that pocket.
7. Check for proper rotation of the pockets using the crucible indexer. Go through one full rotation of the hearth to make sure the indexer is operating correctly. Position the desired crucible for evaporation in the exposed position and turn off the power to the crucible indexer.
8. Inspect the operation of the shutter by cycling the SHUTTER switch. Observe the shutter movement and position. The shutter should be over the hearth in the closed position thus shielding the samples from the source and should be out of the line of sight between the source and samples in the open position. Place the shutter in the closed position. The red light above the shutter switch should be off.

9. Turn on the power to the crystal monitor and enter into the program mode. Enter the density and Z ratio for the first metal you will deposit. This information is on the card you placed in the cardholder for that metal. Exit the program mode and check the crystal lifetime. If the readout is greater than 30%, replace the crystal. The crystals will last far beyond 30% so don't change it early. If you don't know how to replace a crystal, seek help. Turn off the crystal monitor.
10. Place your samples on the center sample holder. The tooling factors for the crystal monitor are set for the center position. If you wish to use a different position, you will need to determine the tooling factor for that position.
11. Inspect the inside of the chamber for metal flakes. If flakes exist, use the vacuum cleaner to remove. Inspect the aluminum foil mounted in the chamber. If the foil seems to not be securely fastened to the chamber, secure the foil at this time by firmly wrapping it around the chamber hardware. Make sure the foil is not touching any electrical feed-throughs or other electrical connections.
12. Remove the cover glass for the sight port and scrub off the deposited metal with a green Scotch-Brite pad. Wipe the glass with IPA and insert into holder.
13. Wipe the sealing surfaces of the door with IPA then close and hold the door shut such that the sealing surfaces mate.
14. Depress the MECH PUMP switch to turn on the roughing pump. Wait several seconds then depress the ROUGH switch to open the roughing valve. The light should change from red to green. Hold the door closed for several seconds, then pull on the door to open. The door should not open. After several minutes of roughing, observe the A Thermocouple readout on the vacuum controller. The gauge readout will start monitoring pressure at 1.0 Torr.
15. Keep track of the time for pump down. When the chamber pressure reaches 90  $\mu\text{m Hg}$  or  $0.9 \times 10^{-1}$  Torr, the rough valve will automatically close. This interlock prevents pump oil backstreaming. Now, depress the ROUGH switch. The light should change from green to red. Shut off the roughing pump by depressing the MECH PUMP switch. The blinking light should go off. Remember, if the chamber is left unattended during roughing, backstreaming could occur if the interlock fails. Enter the time of rough down in the logbook. Contact the cleanroom manager if the rough down time differs by more than 30 seconds from the previous user.
16. Depress the HI VAC switch to open the gate valve. The light should change from red to green. Observe the A thermocouple readout. Once this readout shows 0.0 Torr, depress the IG1 button on the vacuum controller to turn on the ion gauge.
17. A base pressure of  $2.0 \times 10^{-6}$  Torr is suggested. Obviously, the lower the base pressure, the fewer impurities will be incorporated into your films. Allow the chamber to pump down to or below this recommended pressure.
18. Once the desired base pressure is achieved, turn on the cooling water supply in the chase by rotating the orange supply and return handles to vertical positions. Turn on the return before turning on the supply. Observe the float on the return end of the line. It should read at least 5 gpm. If it does not, contact the cleanroom manager or technician. Observe the base pressure of the chamber after the water is turned on. If the pressure has increased, there is a possibility of a water leak that must be corrected before any deposition.



**Figure 3 Process Chilled Water Lines**

19. Pull the main breaker switch for the e-beam power supply up to the ON position. Wait approximately 1 minute to allow the electronics to warm up.
20. Place the key into the High Voltage Control Module. Insure that the voltage and current adjust knobs are zeroed on the High Voltage Control and Electron Gun Control modules respectively, and turn the key to the on position. At this point, all the interlock lights on the left side of the High Voltage Control and Electron Gun Control modules should light up except for 2 GUNS 1 TANK and 2 GUNS 2 TANKS.



**Figure 4 High Voltage Control, Electron Gun Control and Sweep Control Modules**

21. Depress the red HV ON button on the High Voltage Control module to turn on the high voltage. This button should illuminate red once depressed. Wait about 1 minute for the electronics to warm up. Slowly turn the voltage adjust knob clockwise to adjust the voltage to 10KV. A value of 10 on the meter indicates this voltage. Do not exceed 10KV!
22. Important! Make sure the current adjust knob on the Electron Gun Control module is at zero!!! Depress the red GUN #1 FIL ON button. Hold down the Emission/Filament toggle switch to indicate the filament current. A value of around 500-600 mA should exist with the adjust knob at zero (this value will decrease as the electronics warm up).
23. Observe from the log book the evaporation rate and filament current for the metal being evaporated from previous runs. Use this information as a guideline for your target filament current. Note that the current required will vary based on the amount of metal in the crucible and the crucible itself.
24. Increase the filament current to 700 mA. At this point, you should see the sweep of the beam on the metal. If you don't, increase the filament current to 750 mA and observe. If you still don't see the beam, reduce the current adjust knob to zero, reduce the voltage adjust knob to zero. Depress the GUN #1 FIL OFF and HV OFF buttons to shut off the controllers and seek help.
25. Once the beam is observed, adjust the longitude and latitude positions with the respective LONGITUDE POSITION and LATITUDE POSITION knobs on the Beam Sweep Control Module such that the beam is centered on the metal.
26. Adjust the sweep amplitude for longitude and latitude using the LONGITUDE SWEEP and LATITUDE SWEEP knobs such that the beam covers most of the metal without hitting the crucible. If the beam hits the crucible, your film will be contaminated and the crucible could be damaged. This is very important when using an aluminum oxide crucible.

27. The sweep frequencies for longitude and latitude are set at 2. This value should not be changed except when evaporating chromium (Cr).
28. Allow the source to soak at this setting for 1 minute. Increase the filament current by 100 mA, inspect the beam position and amplitude and adjust accordingly. Allow the source to soak at this increased current for 1 minute. Continue soaking for 1 minute at 100 mA intervals until the target filament current is reached. If Ni is being deposited, the soak times should be 10 minutes with 50 mA intervals due to the poor thermal conductivity of this material. If you try to rush soaking Ni you can be guaranteed that a cracked crucible will result. As the target filament current is approached, the chamber pressure will start to increase. This is an indication that evaporation is taking place. All source metals will exhibit this behavior except for Ti, Cr and sometimes Al. These metals will cause a decrease in chamber pressure upon evaporation due to oxygen gettering. Additionally, Cr sublimates so a melt will not be observed. Rather, observe the chamber pressure to determine if sublimation is occurring. Be careful with Al also. This material will wet the crucible and attempt to climb out of the crucible if heated too quickly. So, ramp and soak Al slowly. If using a graphite crucible, use as low a filament current as possible to avoid formation of aluminum carbide. Once aluminum carbide has formed, the deposition rate will drop to zero and the crucible is useless. With all metals, wait for the chamber pressure to stabilize once the target current is reached to insure a constant deposition condition.
29. Turn on the crystal monitor, enter the program mode and check the density and Z ratio values. Exit the program mode and depress the START button. The elapsed time should be indicated on the lower left-hand corner of the screen. While depressing the ZERO button momentarily on the monitor, depress the SHUTTER switch to open the shutter. At this point a deposition rate greater than zero should be observed and the thickness value in Å units should be increasing.
30. Adjust the filament current to obtain the desired deposition rate. Log the required parameters of your deposition run.
31. When the film thickness is 5 – 10 Å less than the target thickness, depress the SHUTTER button to close the shutter. The red light above the switch should turn off.
32. Ramp down and soak the source at the same interval and time as the ramp up and soak of the source. This is important to insure that the crucible does not crack.
33. After soaking at the minimum filament current to observe the beam, turn the current adjust knob to zero and depress the GUN #1 FIL OFF button on the electron gun control module to shut off the filament current. Turn the voltage adjust knob on the high voltage control module to zero and depress the HV OFF button to shut off the high voltage. Turn the key to the off position. Shut off the breaker for the main power.
34. Allow the crucible to continue cooling without changing its position for at least 10 minutes. Cooling water is supplied directly to the exposed crucible. If the crucible is rotated out of its exposed position within the required time, the crucible and hearth could be damaged.
35. If another deposition is required, upon completion of the cool down period, turn on the power to the crucible indexer and select the next crucible to be used for deposition. Modify the density and Z ratio values for the Crystal monitor to match the metal to be deposited. Refer to the log and observe the filament current used for this particular metal and use this as a guideline for your deposition. Follow steps 19-34.
36. Note the lifetime of the crystal and log it. Turn off the power to the crystal monitor. Press the IG1 button on the vacuum controller to shut off the ionization gauge. Depress the HI VAC switch to close the gate valve. The light should change from green to red. Wait until the gate valve operation is no longer audible. Depress the VENT switch. The light should change from red to green. Observe the A thermocouple gauge readout on the vacuum controller. The chamber pressure should be increasing. Wait until the door swings open and nitrogen gas is heard escaping from the chamber. Depress the VENT switch to shut off the nitrogen gas. The light should change from green to red.
37. Inspect your gloves and replace them if they are torn or soiled. Remove your sample, remove the crucibles and store them in the proper place. Wipe the sealing surface on the chamber and o-ring on the door with IPA (not acetone), close the door and hold it shut.

38. Depress the MECH PUMP button to turn on the roughing pump. Wait about 5 seconds, and then depress the ROUGH switch to open the roughing valve. Hold the door for several seconds, and then try to open the door. The door should remain closed. Observe the chamber pressure on the A Thermocouple Gauge readout. The pressure should be decreasing. Remove the cards from the cardholder corresponding to the crucibles removed from the chamber.
39. When a chamber pressure of 90 $\mu$ m HG is indicated and the rough valve has closed depress the ROUGH switch. Depress the MECH PUMP switch to shut off the roughing pump. Depress the HI VAC switch to open the gate valve and observe the chamber pressure. The pressure should indicate 0.0 Torr in several seconds after opening the gate valve.
40. Shut off the cooling water for the chamber and power supply. Remove the key from the e-beam power supply and return the key to its designated location.