Standard Operating Procedure

Use of the K.J. Lesker AXXIS Physical Vapor Deposition System (PVD)

Facility: K. J. Lesker PVD System
C16 Engineering Research Complex
Electrical and Computer Engineering

Lab Director: Karl Dersch
C139 ERC
353-1959

Scope: This SOP details the general procedure for operation of the department's Physical Vapor Deposition (PVD) system.

Last Revision: 9/8/2010

Introduction:

The AXXIS Physical Vapor Deposition System, made by K. J. Lesker, is equipped with two sputtering guns, a four pocket e-beam (7cc), and a substrate glow discharge system for substrate cleaning. The substrate platen can be rotated during deposition, and optically heated up to 300ºC. The two sputtering guns include one 2" DC and one 2" RF gun. A quartz crystal monitor can be used to monitor film thickness during e-beam deposition. Two process gases can be introduced into the chamber through needle valves. This system is typically used for metal deposition, however some oxides can also be deposited by RF sputtering, or e-beam deposition.

Applications:

PVD is effective for depositing metals (Au, Ti, Al, Pt, etc.), as well as oxides (ITO, HfO, etc.).

System and Experiments:

Schedule system usage online at www.egr.msu.edu/erc-cleanroom

Typical Operation:

Safety First:

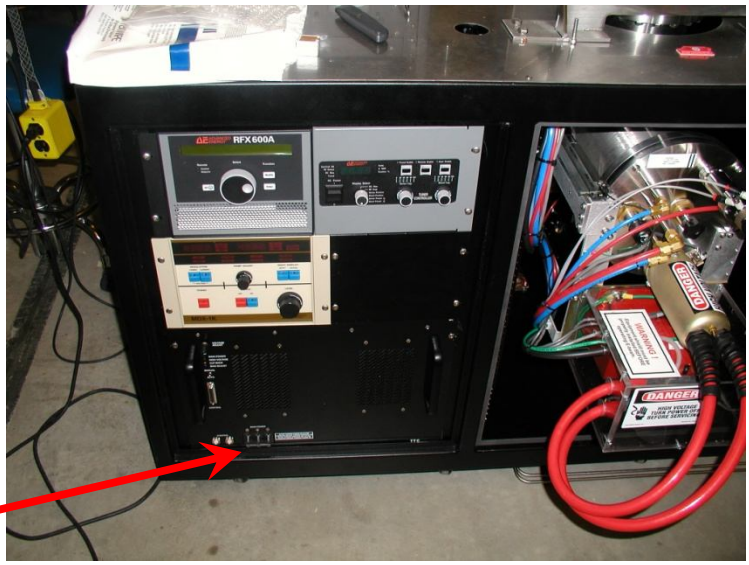
1) Within the PECVD system, high voltages are used. Be sure the safety guards on the system are in place, and there are no exposed wires on the system.

2) Ultraviolet light emits from the PECVD system while there is a plasma. Avoid staring at it for extended periods of time.
3) The sample platen is maintained at 300ºC. This can cause burns, melt your gloves, and melt polymer tweezers. Care must be taken to use metal tweezers (often using two tweezers to help get under a wafer), and to not touch the sample platen.

Operating Procedure:

1) Log in to the logbook. Include the date, your name, a description of your run, and any difficulties or other comments that help to maintain the system.

2) Verify the system power switch is on.

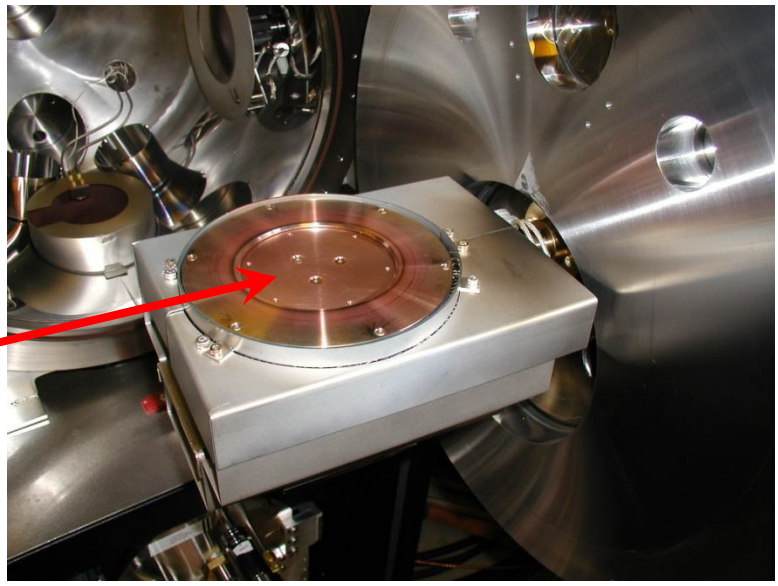


System power

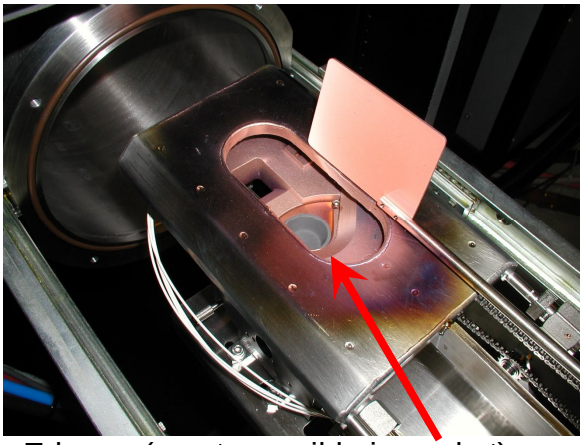
3) Verify the system is at atmospheric pressure then open the chamber door. If it is not at atmospheric pressure, then vent the chamber.

4) Place your substrate (and shadow mask if used) onto the platen. Use clips or razor blades to hold substrate and mask down. The 4-40 bolts must not extend through the platen (if they do, they will catch on the wire mesh and damage the system). Six 4-40 taps are distributed on a 3.5” diameter bolt center. For e-beam deposition, the sample stage will be turned upside down.

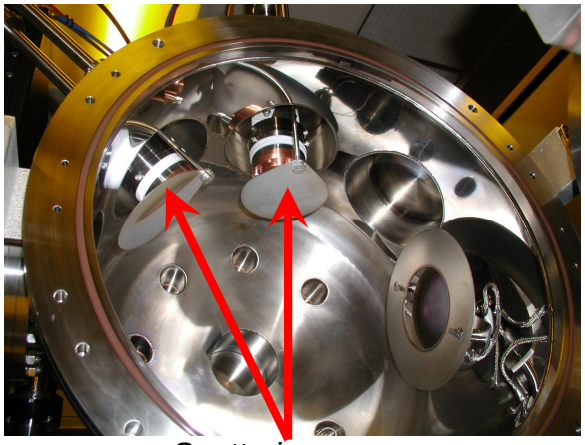
Sample Platen



5) Verify the e-beam shutter is closed (it will break off when opening or closing), then load target materials into the source (sputtering guns or e-beam)



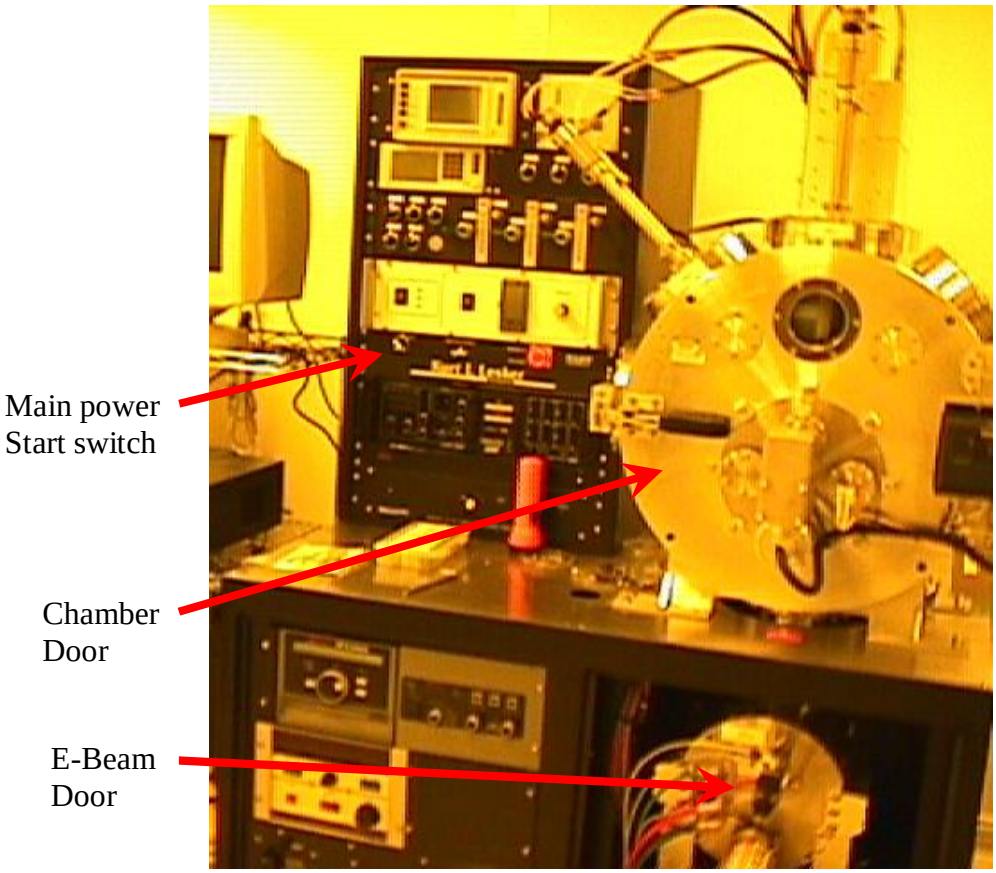
E-beam (empty crucible in pocket)



Sputtering guns

6) Check the chamber door seals for cleanliness. After cleaning, then close and latch the chamber door. Close the e-beam door.

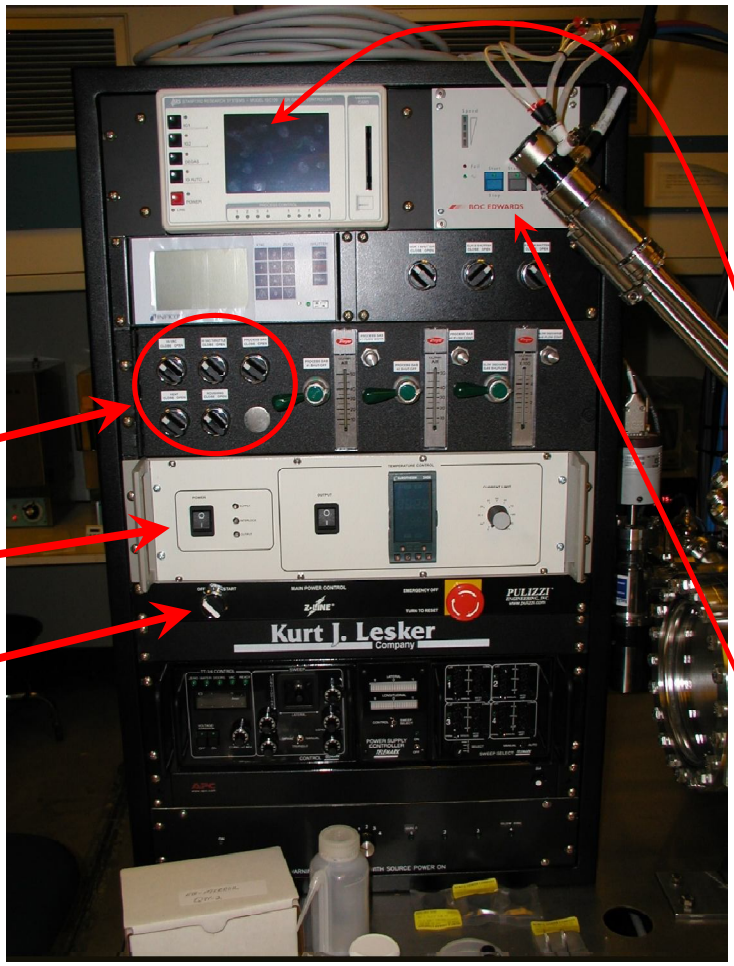
7) Turn the main power switch to “Start” (this is a momentary switch that will return to the “ON” position when released).



8) Close the following three valves:
   a. “HIGH-VAC Throttle” valve
   b. “Process Gas” valve
   c. “Vent” valve

9) Open the “Roughing” valve.

10) Open the “HI-VAC” valve



11) Press “Start” on the BOC EDWARDS vacuum pumping system controller. Hold the E-Beam door closed so a vacuum seal can be obtained.

12) Turn on the SRS vacuum gauge controller, and monitor pressure reading of the thermocouple gauge until BOC EDWARDS vacuum system controller reaches the green LEDs. The turbo pump will automatically turn on when the proper pressure is reached. Do <u>not</u> turn on the ion gauge until the pressure is below 10^{-4} Torr. Do <u>not</u> leave the ion gauge on for long periods of time.

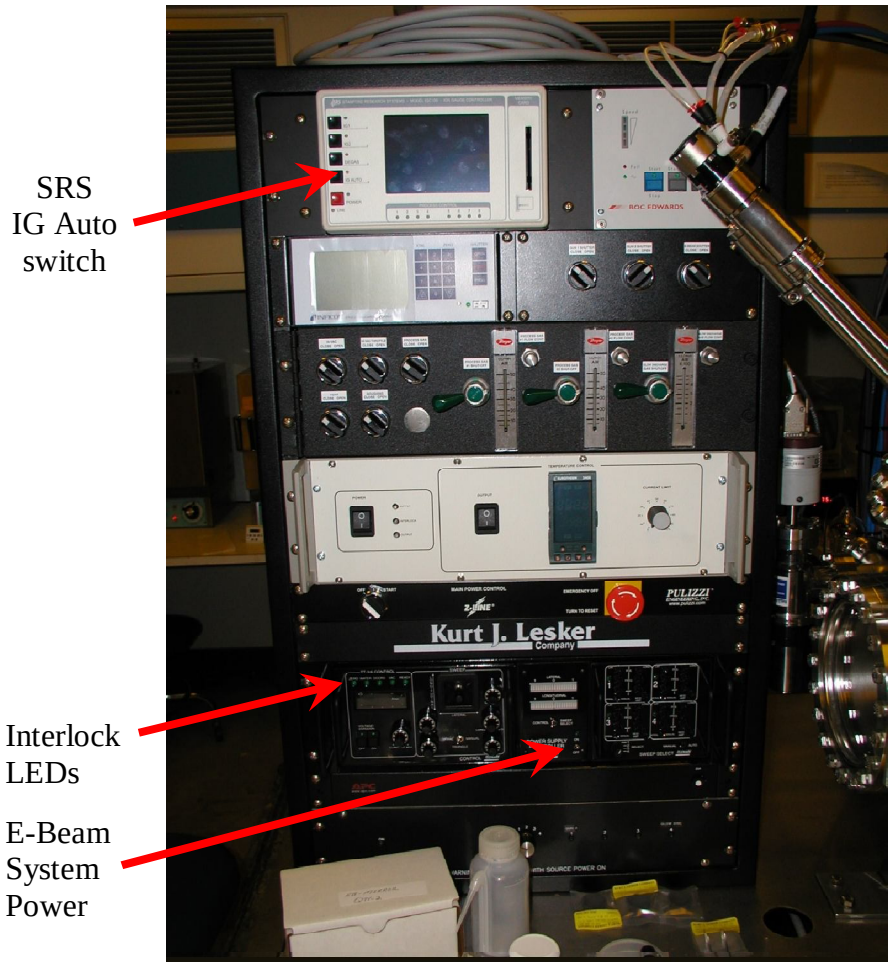
13) The system should pump down for 4-6 hours (or more) to reach 10^{-6} Torr.

14) The ion gauge can be turned on using the IG Auto button on the SRS vacuum gauge controller.

15) Optional: heating the substrate can be done at this point by:

a. Turn on the “Temperature Control” power.

b. Turn on the substrate heater “OUTPUT”
c. Adjust current level to increase temperature to desired setpoint.



16) Turn on the power to the E-Beam system.

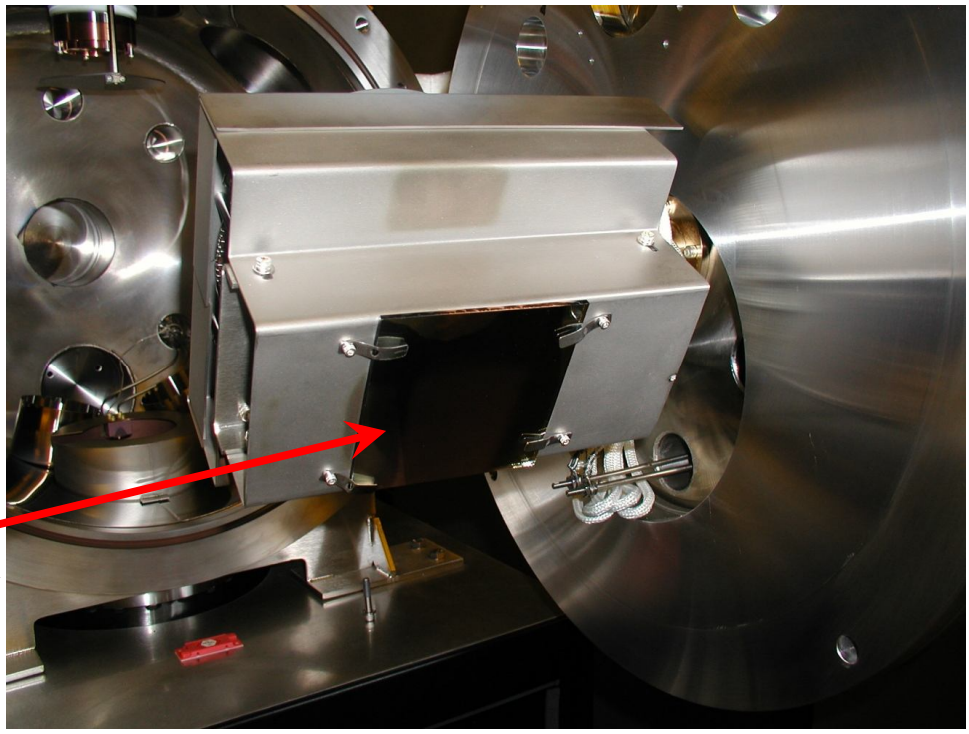
17) Verify the interlock lights are all on (five green display LEDs on the TT-3/6 control). These interlocks are for both e-beam and sputtering.

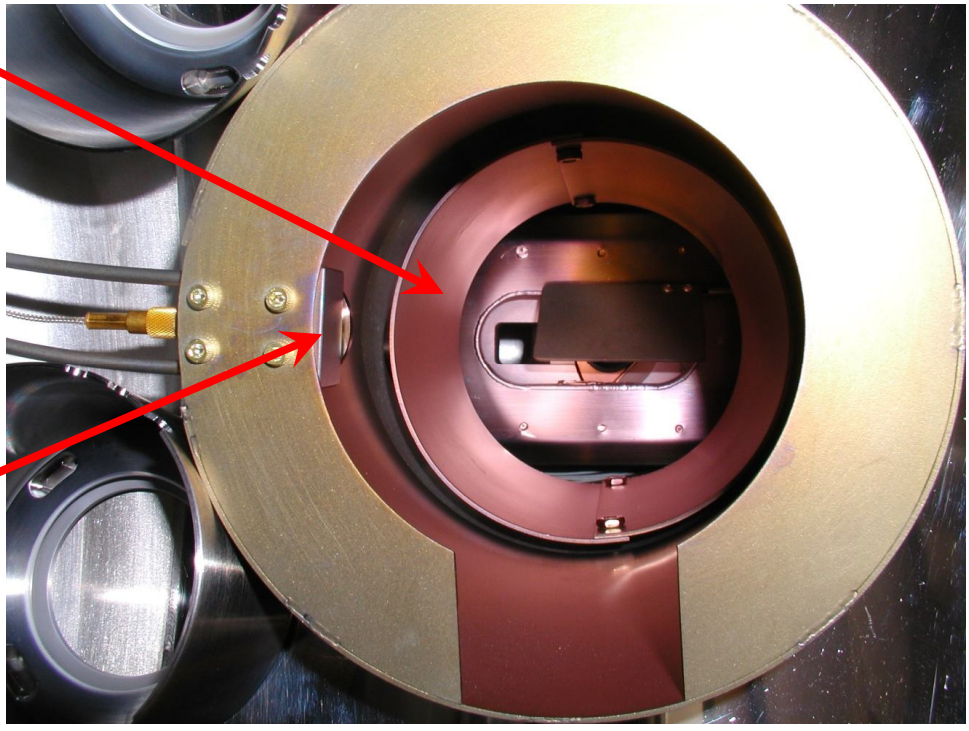
From this point, continue to either the E-Beam Deposition Procedure, or to the Sputtering Deposition Procedure below:

E-Beam Deposition Procedure

18) Monitor the SRS Pressure gauge display for the vacuum level (turn on the SRS IG Auto switch). It is recommended a vacuum level of $< 5\times10^{-6}$ Torr.

19) When the desired vacuum level is reached, loosen the locking screw and rotate the sample stage to align the mirror on the back side so you can look down into the e-beam system. A flashlight can be used for better vision.





20) Verify e-beam shutter switches open and close, and set to “open”.

21) Set the Sweep controller is in “Control” mode.

Set to “CONTROL” for joystick adjustments of the beam

22) Using the joystick, manually center the e-beam until the lateral/longitudinal LED bar codes are near the middle (←→ for longitudinal, ↑ ↓ for lateral control).

23) Turn down the emission current, then turn on the “voltage emission”, notice HV red LED on bottom left.

24) Increase the emission current while looking at the mirror (into the e-beam system) until you start to see a glow (should be less than 30 mA to see this).

25) Use the joystick to adjust the position of the e-beam to center it on the target material.

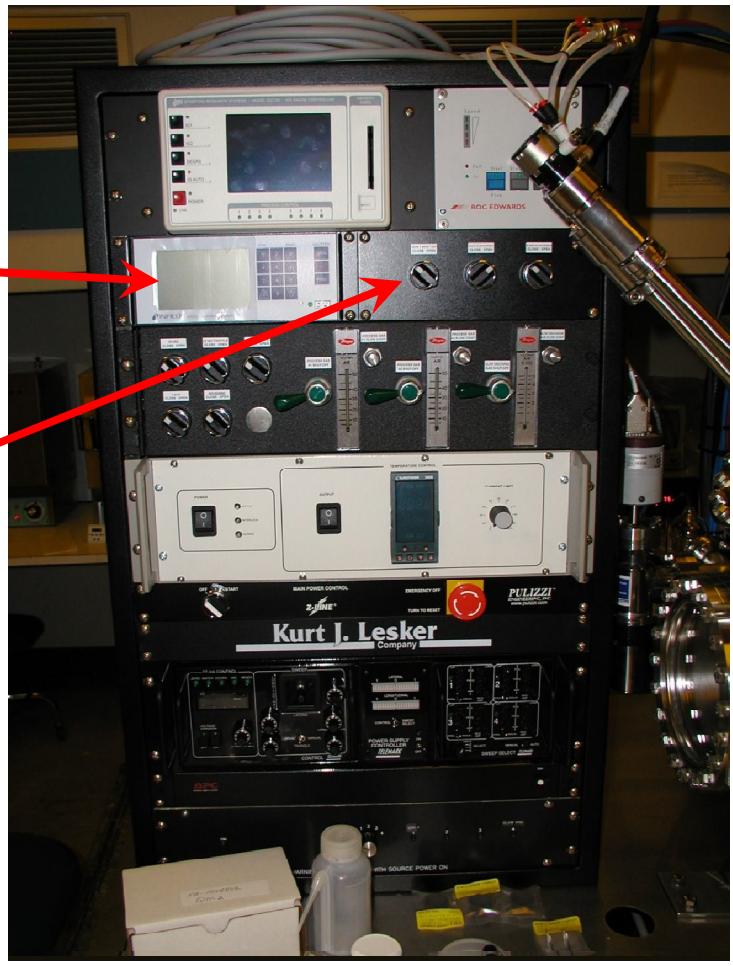
26) Select sweeping pattern desired (e.g. spiral, triangle, manual), and increase the emission current until the target begins to melt. For reference, the deposition of titanium onto a glass substrate showed:

Emission current of 100mA gave 0.2-0.3 Å/s
Emission current of 170mA gave 0.6 Å/s and yielded 1000Å in 30min

27) After the target is melted, close the e-beam shutter.

28) Rotate the sample stage into position (samples facing down to e-beam source), note markings on sample/mirror stage rotation handle.

29) Turn on the Inficon quartz crystal monitor, and zero it.



30) Open e-beam shutter.

31) Readjusted emission current while observing deposition rate as needed.

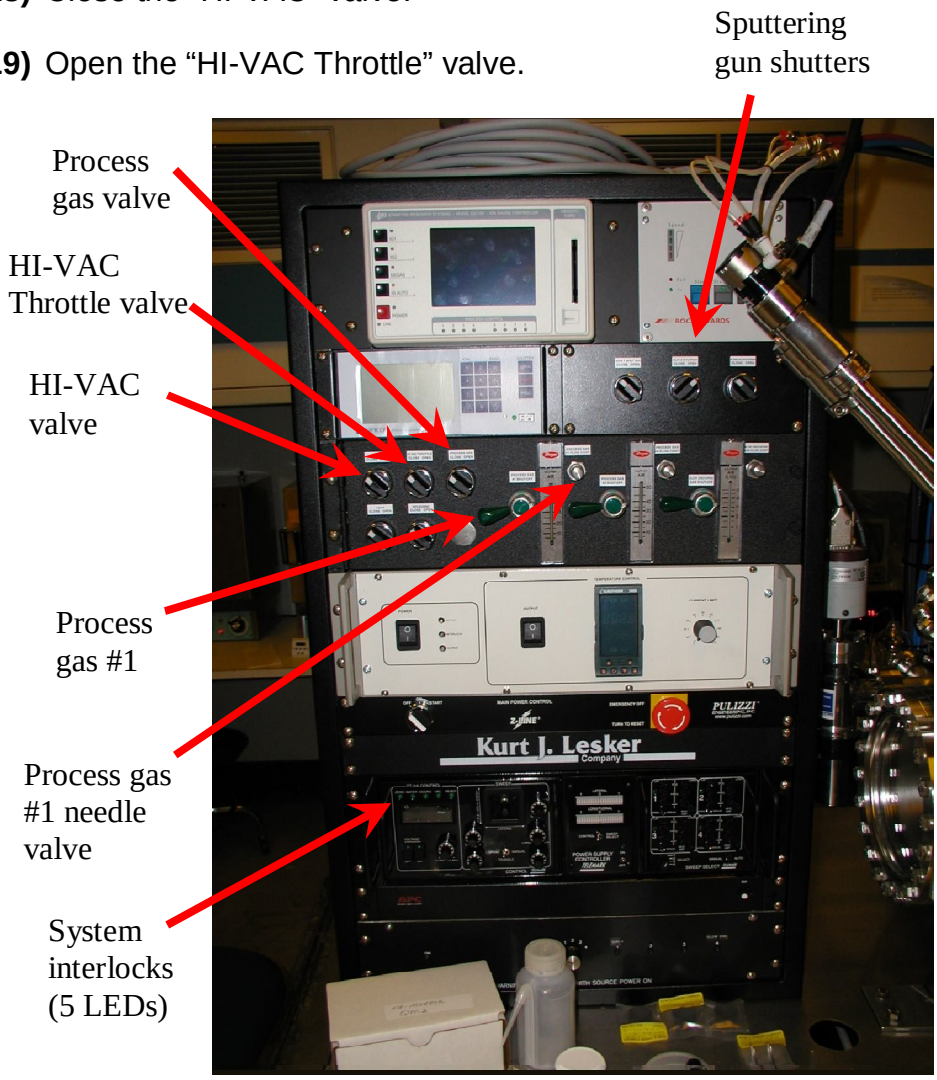
32) When finished:

a. Close e-beam shutter
b. Adjust emission current to zero
c. Turn off voltage emission source
d. Turn off power supply controller
e. Turn off deposition monitor
f. Allow substrate to cool by maintaining vacuum and water flow for 30 min. prior to venting.
g. Vent the system. See venting procedure section in this manual.

Sputter Deposition Procedure

18) Close the “HI-VAC” valve.

19) Open the “HI-VAC Throttle” valve.



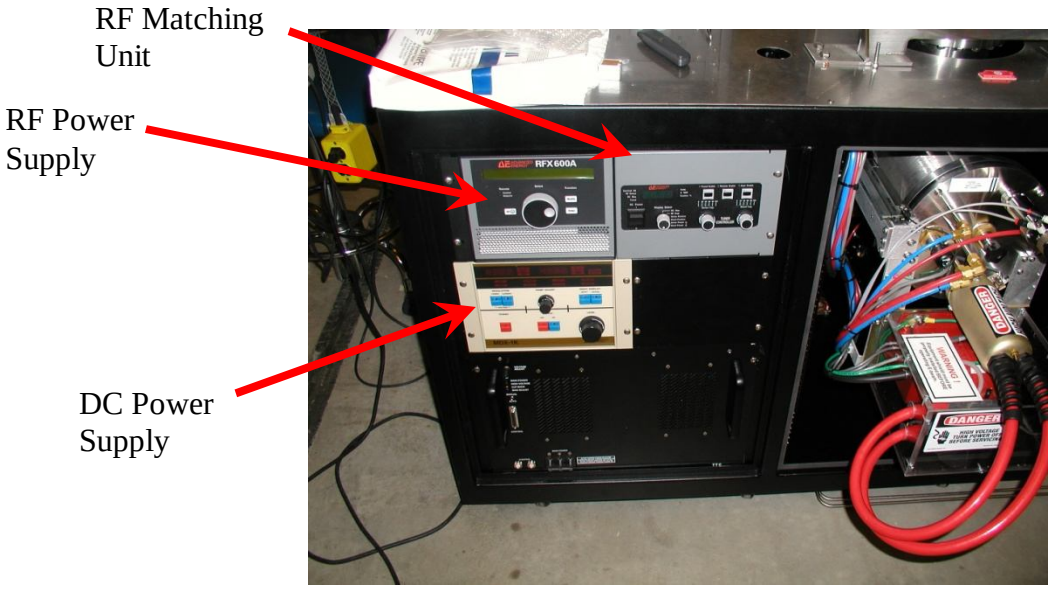
20) Close the sputtering gun shutter.

21) Open “Process Gas” valve.

22) Slowly open the “Process gas #1” valve. Then adjust the “Process gas #1 needle” valve while monitoring the vacuum. Stabilize the pressure to approximately 50 mTorr (thermocouple gauge and/or CM1 gauge).

23) Verify the water system interlocks are all satisfied, then turn on the power supply for the sputtering gun (DC or RF supply depending on which sputtering gun you are using). If using the RF supply, also turn on the RF Matching Unit.

24) Increase the power to the desired level. A plasma should be achieved near 100-200 W.



25) It is a combination of gas pressure and power that must be tuned to achieve a sputtering plasma (glow around the sputtering gun).

26) For RF sputtering, the Matching Unit should automatically adjust for a minimum reflected power. If the reflected power is too high (> 30 W), the RF supply can be damaged. In this case, reduce the power, and contact Karl Dersch to assist in the adjustment process.

27) When a stable plasma is achieved, open the shutter and begin the deposition. Film thickness cannot be monitored by the quartz crystal monitor for sputtering deposition, therefore use the chamber pressure, power level, and target material information to look up the sputter deposition yield.

28) Monitor the system while depositing. Sparking at the sputtering gun can occur if the settings are incorrect, or if there is a metal flake between anode and cathode. If sparking is occurring, reduce the power to the sputtering gun, and contact Karl Dersch.

29) When finished, close the sputtering gun shutter. Then turn down the power to the gun and turn off the sputtering gun power supply.

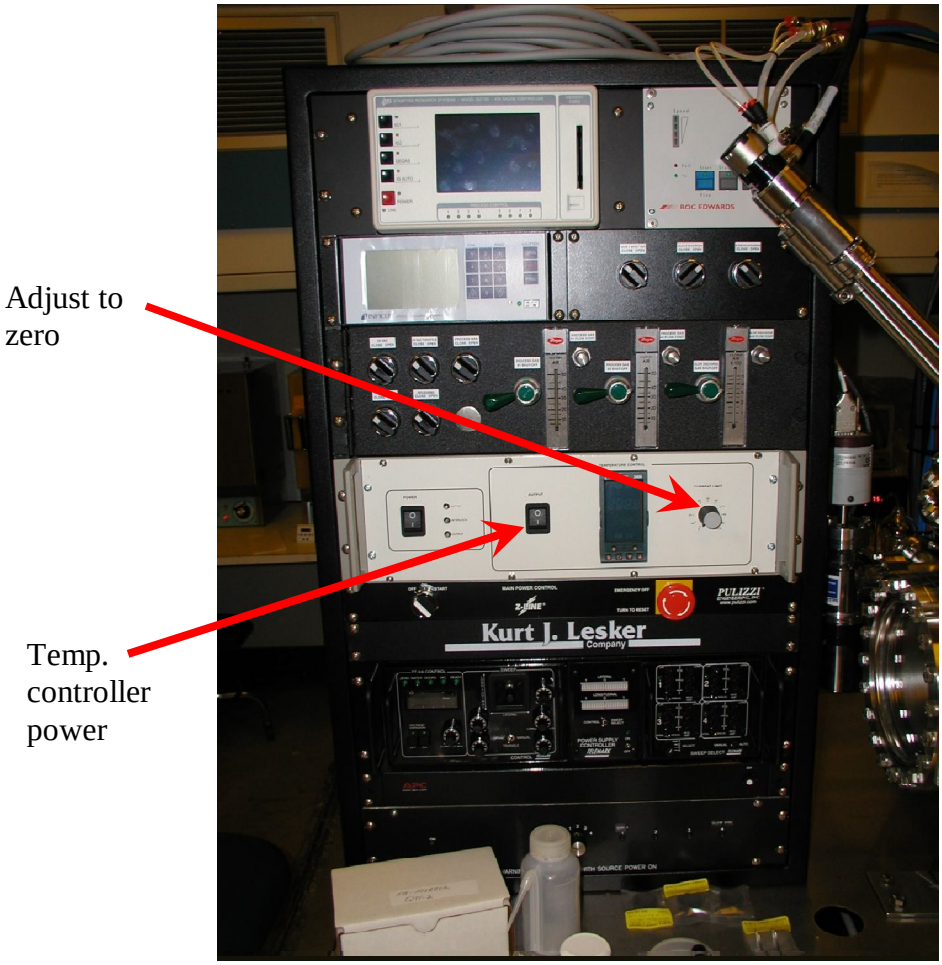
30) Allow the system to cool for 15 minutes (guns will be hot). Then close the “HI-VAC Throttle” valve.

31) Close the “Process Gas #1” and the “Process Gas” valves, and vent.

Venting Procedure

******Never vent the system if the stage is above 80°C******

33) If used, turn OFF power on substrate heater, adjust to zero, and turn OFF the Power Switch on the temperature control



34) Before venting allow the chiller water to cool the system for ~30 min.

35) Turn off the IG Auto & IG1 buttons on the SRS monitor.

36) Turn off the vacuum pump by pressing the “Start” button in BOC EDWARDS control system.

37) Wait for the speed to reduce until speed indicator green lights turn OFF (only red LEDs are showing on the BOC EDWARDS vacuum control system). Then open the “Vent” valve.

38) Release chamber handle, but do NOT open the chamber door (vacuum in the chamber should be holding the door closed at this point).

39) After the chamber is vented to atmospheric pressure the chamber door will open on its own if you released the chamber handle as noted above.

40) Close the “Vent” valve.

41) Turn OFF power in SRS.

42) Turn OFF main system power.

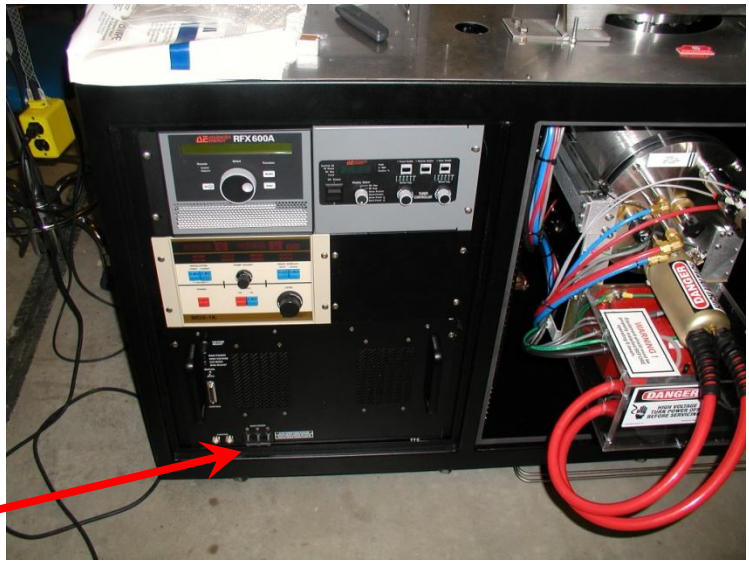
43) Turn Substrate holder to its original position to avoid damage while opening.

44) Take out your sample.

45) Verify the shutter is closed on the e-beam system. Then take out your source materials.

46) Clean system with vacuum cleaner if necessary.

47) Note in the logbook the run conditions, and any maintenance needed (first step in repair is knowing there is a problem).



System power