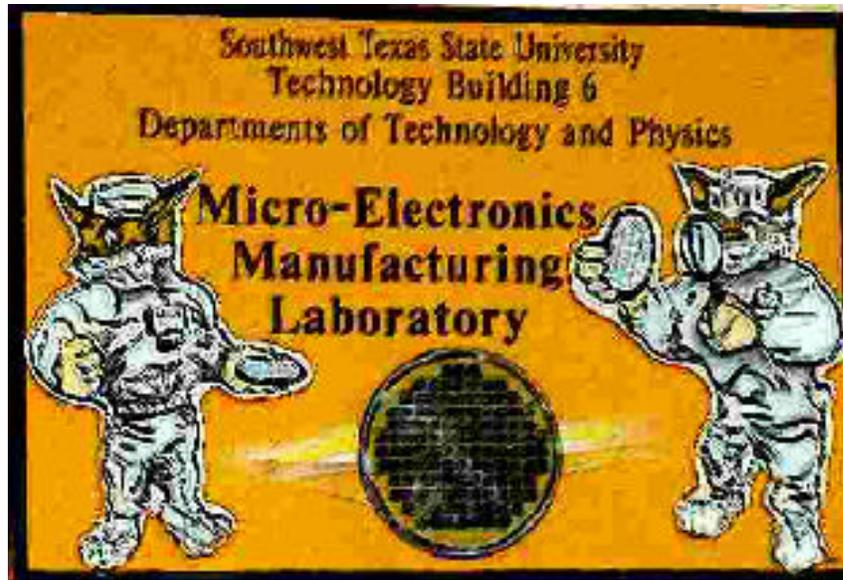


# Manual Physical Vapour Deposition System



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## 1.0 Content:

Manual explaining how to operate the system.

Background explaining the deposition technology.

Trouble-shooting / FAQ.

Long term Maintenance Manual.

## 2.0 Operation Manual:

### 2.1 To start up the system:



1. Open the **Air Pressure Valve**: the air pressure should be 60 psi.
2. Energize the outlet strip. Ensure the **Mechanical Pump** starts.
3. Close all valves. Ensure the **Deposition Power** is off (A) and disabled (B).
4. **Main Power Switch** to on.
5. Open **Turbo Backing Valve**.
6. Switch the **Turbo Controller Power** on.
7. Wait until the **Foreline** pressure is less than 0.1 torr.
8. Start the **Turbo**.

## 2.2 Pump Down Procedure:



9. Close the door and close the **Vent Valve** (a).
10. Close the **Turbo Backing Valve** (b)
11. Open the **Rough Valve** (c).
12. If the chamber pressure is below 0.1 torr (A) and the Piranni Setpoint Light comes on (B), close the **Roughing Valve** (c).
13. Open the **Turbo Backing Valve** (b).
14. Open the **High Vacuum Valve** (d).
15. Allow the chamber to pump down to less than  $1 \times 10^{-4}$  torr (20 minutes) (E)

## 2.3 Venting Procedure:



16. Adjust **Power Control CCW** (A) and turn off **Deposition Power** (B).
17. Ensure **Deposition Power** is disabled (C).
18. Allow source to cool for 5 minutes to prevent filament oxidation.
19. Turn off the **High Vacuum Valve** (D).
20. Turn on the **Vent Valve** (E) and allow chamber to equalize to atmospheric pressure; you should hear a click and if the chamber was under vacuum you will hear a hissing sound. By placing your finger on the bottom of the **Vent Valve**, you can check the inlet of air (F). If you do not hear a click check if the air pressure is 60 psi (1).
21. Allow the chamber to equalize to atmospheric pressure.
22. When the air flow has come to a stop open the door carefully. It might stick (ask Richard if we can put a light overpressure on the chamber).

## 2.4 Deposition Procedure:



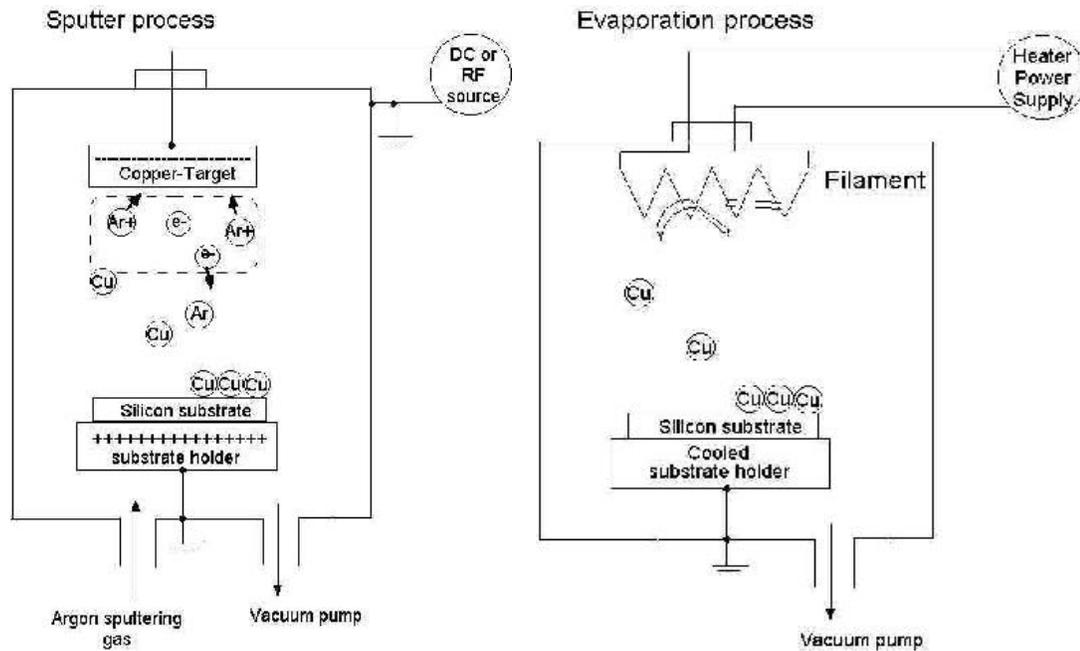
23. Bring the system to air and open the chamber door.
24. Remove the **Mirror Assembly**.
25. Remove the **Substrate Hanger** and place it into the loading fixture.
26. Load substrates on hanger.

27. Fold source material into a narrow U (0.1" X 0.5").
28. Place source material onto the **Filament** near the center - use tweezers to crimp the source loop firmly to the filament - Be careful as filaments that have been heated are very brittle!
29. Repeat (5) and (6)
30. Carefully suspend the **Substrate Hanger** from the hanger clip in the chamber.
31. Place the **Mirror Assembly** between the door and the Source such that the filament is visible in the bottom mirror.
32. Pump down the system to  $1 \times 10^{-4}$  torr (this might take 25 minutes).
33. Ensure **Deposition Power Control** is fully CCW (A).
34. Turn on **Deposition Power** (B) and Enable **Deposition Power** (C)
35. Slowly adjust **Deposition Power Control** CW until the **Filament** glows dull red (A).
36. Allow to soak for 30 seconds.
37. Adjust **Deposition Power Control** CW until the source material melts into a ball on the Filament (A).
38. Immediately adjust **Deposition Power Control** CW until the source material wicks into the **Filament** (A).
39. Adjust **Deposition Power Control** fully CW to completely evaporate the source material (A).
40. Allow to soak for 10 seconds.
41. Adjust **Deposition Power Control** fully CCW (A) and turn off (B) and disable (C) the Deposition Power.
42. Allow the source to cool for 5 minutes before venting the system. This will reduce filament oxidization.

### 3.0 Deposition Technology:

Physical Vapour Deposition (PVD) is used to plate objects with a thin layer of another material. For example a protective coating on tools, a shiny layer on a bracelet, or an aluminum layer on a silicon wafer. The two most used PVD technologies are sputtering and evaporation. At the Physics Department of SWT we have two sputter systems. The micro-fabrication facility has two evaporation units. Both sputtering and evaporation are normally done in a vacuum chamber. Atoms and ions of the to be deposited material are introduced in the vacuum by heating the source material (evaporation) or by bombarding the source material with high-energy argon-ions (sputtering). Just like in your bath-room, those atoms will condense on all cold surfaces in the vacuum chamber, including the substrates. A graphical representation of both techniques is depicted in the figures below. In an evaporation system the source material is heated, so that part or all of it will evaporate. In a sputtering system high-energy argon ions bombard the source material, called the tar-

get. Part or all of the momentum of the incident argon ions will be transferred to the target atoms. As a result some of the target atoms will be released into the vacuum.



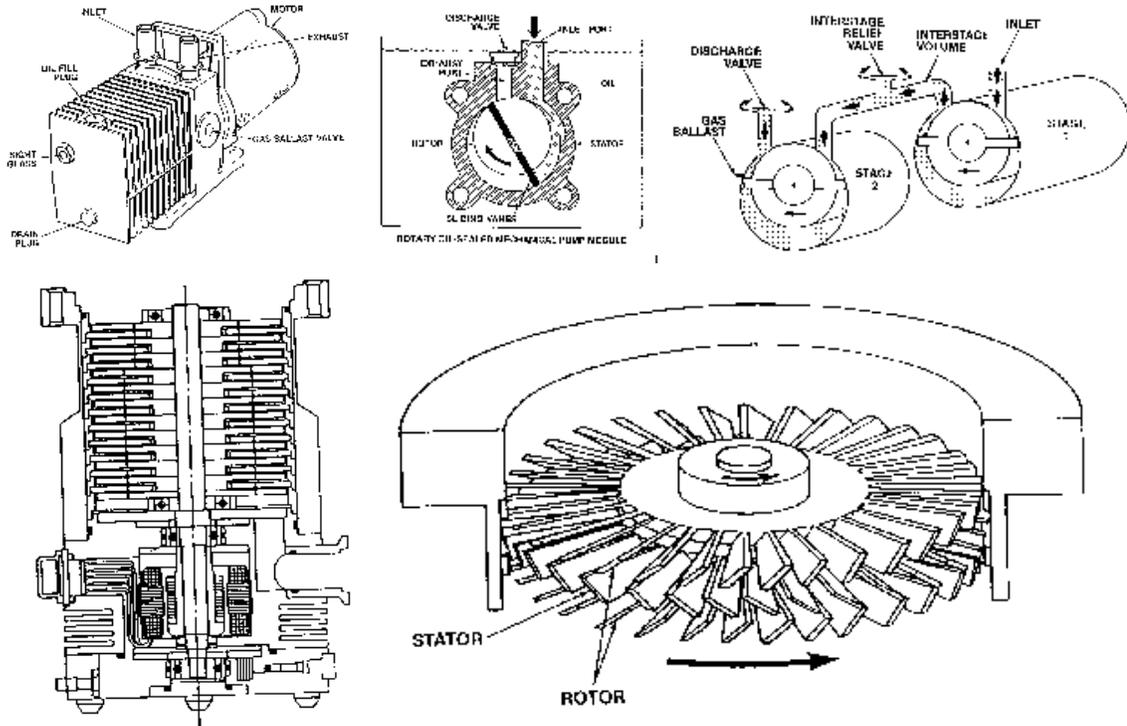
The vacuum is important for both deposition processes since it promotes a contaminant free film. For the sputter technique, a low pressure is necessary in order to ignite and maintain the plasma. For the evaporation technique a low pressure is necessary in order to reduce filament oxidation.

In order to use the heater in this PVD system the vacuum needs to be better than  $10^{-4}$  torr. In order to evacuate the chamber to these low pressures two different type of vacuum pumps are used:

A mechanical oil-sealed rotary pump (760 torr to 0.01 torr). This pump has oil in it for a number of distinct reasons (see figure below), i.e. lubricant, sealant, coolant, and a hydraulic fluid. This oil can be a source of contamination of your vacuum system. The oil backstreaming of mechanical pump increases with lower pressure. Pressures below  $10^{-1}$  torr should be avoided. Never pump on a small vacuum chamber with a large mechanical oil-sealed pump. Another way to avoid oil contamination is to vent the intake of the rotary pump after you have switched it off. Very often the pump consists of two or more stages that are put in series (see the figure below). The pumping speed decreases drastically below 0.1 torr.

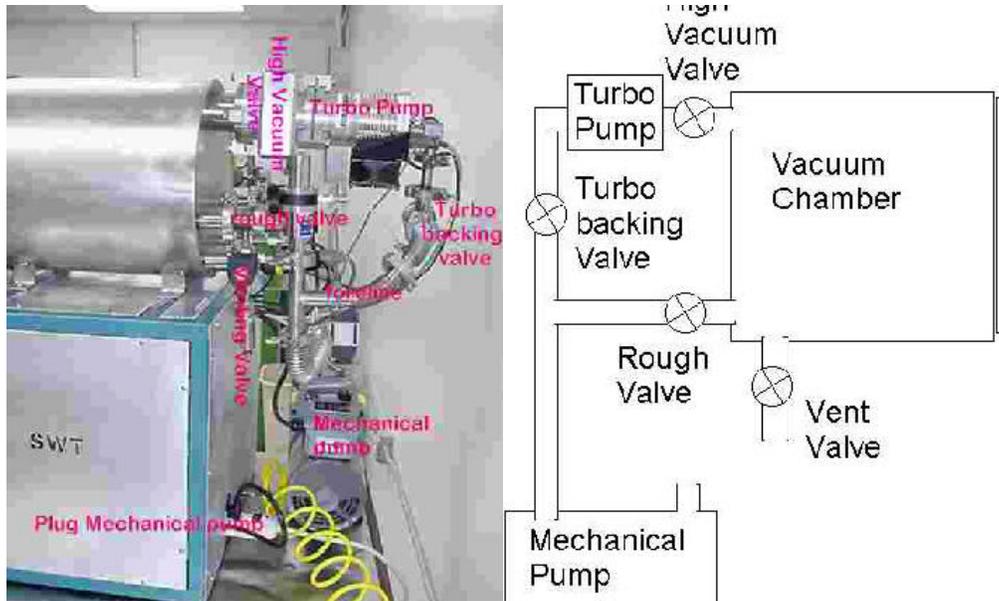
A turbomolecular pump (0.01 torr -  $1 \times 10^{-9}$  torr). These pumps are very clean. They pump by using a high-speed rotating surface to give momentum and direction to gas molecules. They are composed of rotating and fixed disks, rotors and stators respectively. The rotors rotate at high speed (9000-90,000 rpm) and literally push the air molecules to the outlet of

the pump. A turbo pump incorporates a precisely balanced high-speed rotating turbine and should never be moved or jolted while it is in operation. Be also very carefully when you vent the system. It is best to carefully vent the system at the turbo pump outlet. **Do Not Dump** the system to atmosphere. This will bend the blades, might cause "dimples" in the bearings, and can cause a catastrophic crash (the rotors will touch the stators). It is best to vent the pump while it is still spinning as the rotational lift of the blades will minimize the loading on the bearings. The PVD system of the Modulab is vented through the foreline. Venting can force accumulated mechanical pump oil vapors into the high vacuum area of the pump. Do not to vent the turbomolecular pump at all if it is not really necessary. Close the high vacuum valve and the turbo valve and switch off the turbo-pump. Never switch off the turbo-pump without closing the high vacuum valve and the turbo valve. Doing so would result is a fast back-stream of rotary pump oil into the system. Most turbopumps are not designed to be operated at atmospheric pressure. If they can be operated at those high pressures, their pumping speed will be slow.



The figure at the left top shows a mechanical rotary pump. Most mechanical pumps are oil sealed (middle top) and consist of more than one stage (left top). At the left bottom a turbomolecular pump is depicted. Rotors and stators are shown in the figure on the lower right.

The figure below shows a picture and a schematic diagram of the vacuum system of the PVD system.



#### 4.0 Troubleshooting / FAQ:

The high vacuum valve does not open: Check if the air pressure is 60 psi. Make sure that the vent valve is closed. Make sure that the powerstrip is energized. Ensure yourself that the main power switch is on. Make sure that the yellow pressure line is connected to the system.

No air pressure: Check the air pressure valve next to the pressure gauge on the wall. Check the compressor in the room next door.

The vent valve does not open: Check if the air pressure is 60 psi. Make sure the deposition power is off and disabled. Ensure yourself that the main power switch is on. Make sure that the yellow pressure line is connected to the system.

The filament does not glow: Make sure that the air pressure is below 10<sup>-4</sup> torr (if not you have to keep on pumping). Try to check the status of the filament in the mirror assembly.

It is not clear to me if we deposited aluminum: The penetration depth of light in metals is less than 50 nm. So if the thin film has a color different from the bulk color, it means that the thin film is less than 50 nm thick. Other ways to check the existence of aluminum is by using a multimeter and measure the film's conductivity.

## 5.0 Long term maintenance:

If the PVD system has not been used for one month or more, it is necessary to run the turbo-pump at full-load at atmospheric pressure for 15 minutes in order to regrease/re-lubricate the bearings. As the PVD system is interlocked, you need to take the turbo pump out of the system. Follow the directions below (see also figure below):



43. Make sure the air pressure valve is open: the air pressure should be 60 psi (1).
44. Unplug the **Mechanical Pump** from the outlet strip; energize the outlet strip (2).
45. Close all valves; **Main Power Switch** to on (3).
46. Remove the **Foreline Connection** at the bottom of the elbow on the exhaust of the Turbo (4). Be careful that the bellows that connect the foreline to the turbo valve will not be damaged.
47. Loosen the clamps securing the turbo to the **Hivac valve** (5). While holding the **Turbo**, remove the clamps. Be careful as the blades of the **Turbo's Cooling Fan** are sharp and cause deep nasty cuts.
48. Place the **Turbo** on a table and let it run for 15 minutes at atmospheric pressure (be careful as on the high vacuum side of the pump, the sharp rotor blades are exposed).
49. Stop the **Turbo** and allow the rotor to come to a stop.
50. Reconnect the **Turbo** to the **Hivac Valve**. The clamps should be at 12:00, 4:00, and 8:00 o'clock.
51. Reconnect the **Turbo Foreline**.
52. Turn off the outlet strip and plug the **Mechanical Pump** back in.
53. Turn on the outlet strip; the system is now ready to be used.