

Thin Film Deposition by Thermal Evaporation

(This experiment requires minimum 3 hrs, plan accordingly!)

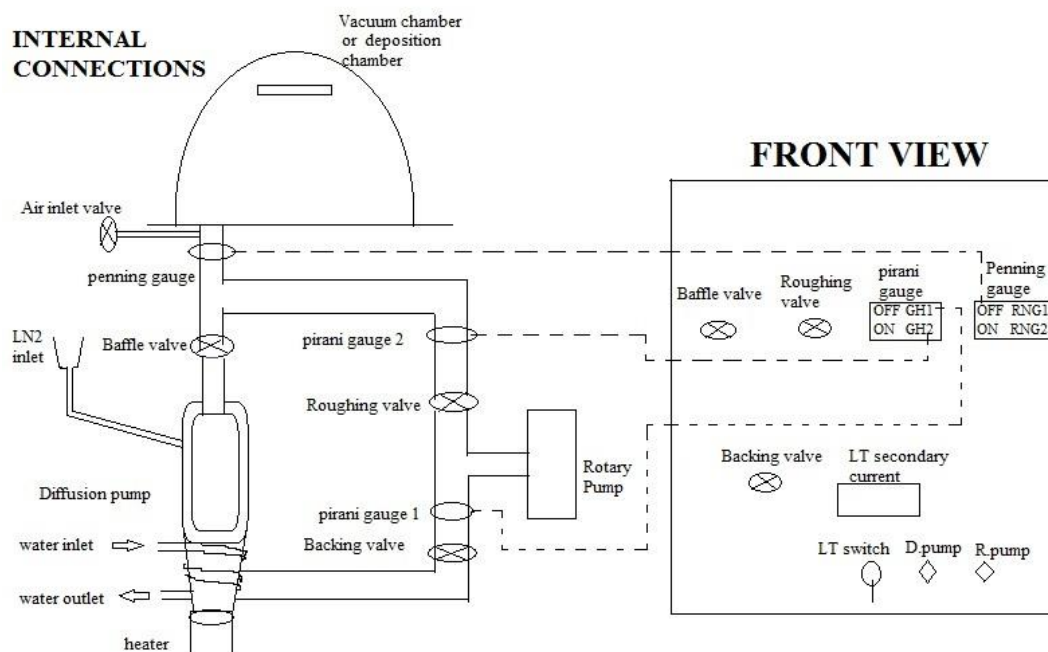
Aim:

Learn about the functioning of the vacuum pumps (Rotary and Diffusion pumps) and precise thin film coating: coating aluminium (new material) on a glass slide (substrate).

I CHECK LIST AND INITIAL MEASUREMENTS

- I. Samples (glass slides) are ready to be placed at proper slots. Label (number) the glass slides with permanent marker and weigh them using analytical balance and record the readings (as W1, W2 etc) and measure its surface area. Now mount them at different slots provided in the vacuum chamber keeping the labeled surface facing towards top.
- II. There is enough material (aluminum) to do deposition: Material should completely cover the heating filament.
- III. Gauge heads of Penning and Pirani are connected.
- IV. Enough Liquid Nitrogen (LN₂) is available and water supply is connected to both Diffusion pump and Thickness monitor crystal setup.

Schematic diagram of the thin film coating unit



Schematic diagram of the thin film coating unit

II PUMPING THE SYSTEM

1. Turn the Mains on. Ensure all the valves are closed (they close clockwise).
2. Turn on Rotary pump and wait for 2-5 minutes. Turn on Pirani gauge and check the vacuum level in GH1 (it should be around 0.05 mbar).
3. Open roughing valve (turn anti-clockwise) to start roughing (to pump the deposition chamber by Rotary pump to get medium vacuum). Wait till vacuum falls less than 0.02 mbar in GH2. Do roughing for about 30 mins.
4. Close the roughing valve. (turn clockwise)
5. Open backing valve (turn anti-clockwise) to pump DP (Diffusion Pump) chamber.
6. Wait till vacuum is less than 0.01 mbar in GH1.
7. Switch ON water pump and make sure water inlet valve to DP is open and water is circulating around the DP chamber. Further, make sure water inlet valve to DTM is closed.
8. **Make sure that roughing valve is CLOSED and backing valve is OPEN.**
9. Turn on the DP. Wait for approx. 30 min for it to become hot.
10. Close backing valve and open roughing valve to ensure that pressure inside deposition chamber and DP chamber is almost same (≤ 0.02 mbar). This might take around 2-3 mins.
11. Close roughing valve and open backing valve again.
12. **Open BAFFLE (gently, it's a plate!) to pump the deposition chamber by DP.**
13. Pour LN2 in the trap through respective inlet till LN2 spills over at its outlet.
14. Wait for 15 mins. Monitor pressure inside the deposition chamber in Penning gauge. Wait till pressure falls below 10^{-5} mbar. **DO NOT keep penning gauge ON continuously (especially during low vacuum).**
15. Continue pumping for at least 45 minutes and keep monitoring the vacuum.

III DEPOSITION (THIN FILM)

16. Ensure vacuum inside the deposition chamber is less than 10^{-5} mbar using penning gauge **RNG 2** (otherwise, wait till you reach it OR inspect for any leak). Note down the value of the vacuum in all three gauges.
17. Open the water inlet valve to allow water to circulate through DTM.
18. Turn on the Digital Thickness Monitoring (DTM) unit.
19. Input proper values of DNT (density in g cm^{-3}) and ACI (Acoustic Impedance in $10^5 \text{g cm}^{-2} \text{s}^{-1}$). Press the corresponding button and press INC or DEC to reach the value. DO NOT change calibrated TFC. In this experiment, since we are using aluminium as a material to be deposited, use following values: DNT= 2.700g cm^{-3} and ACI= $8.830 \cdot 10^5 \text{g cm}^{-2} \text{s}^{-1}$. Further, these values are already stored in one of the Film numbers (i.e. 9).
20. Press STR button to monitor thickness and deposition rate.
21. Turn on LT MAIN (switch). Slowly increase current (by rotating the variac; variable voltage knob) in primary (of the transformer) to reach desired deposition rate (keep monitoring the light due to heating of the filament (inside the vacuum chamber)).
22. Quickly press STR in thickness monitor again (to start from zero thickness). You would also observe a drop in the vacuum during this process
23. After reaching desired thickness. Decrease current slowly. Press STP button in thickness monitor to stop monitoring. **Note the values in the DTM at this stage and at the end of the experiment.**
24. Turn off the LT switch.
25. **If you want to check the quality of the coating immediately (on the same day), you have to skip next steps and follow the steps in the sections V and VI (Vent the chamber and analysis of the film).** It is advisable to do next day with a fresh start.
26. Turn OFF the DTM (thickness monitor) unit.
27. Close **BAFFLE** and turn OFF Penning Gauge, if you have kept it ON.

IV Shut Down the vacuum system

28. Ensure the BAFFLE is closed.
29. Turn OFF DP. Keep doing backing (i.e. backing valve open) and let water flowing through DP as well as DTM and wait till the DP is cooled to room temperature (about 30 minutes).
30. Close the backing valve. Turn OFF Rotary Pump.
31. Wait for 5 min, and close water inlet to DTM and switch off the water pump.
32. Turn OFF the mains.

V Vent The Chamber

33. Venting the deposition chamber can be done after completion of Section 3. But it must be ensured that the BAFFLE is closed.
34. Open the inlet valve to allow air going inside chamber.
35. Open the Chamber Door, take out samples, and put everything back.
36. Do roughing for approx 10 mins to maintain some vacuum inside the chamber.

VI Analysis of the thickness of the film

Method A

37. After taking out (carefully) the coated glass slides from the chamber, weigh them (i.e. $W1^*$, $W2^*$). **Account for the thickness of the film by comparing the weights difference with surface area.**

Method B

38. After taking out (carefully) the coated glass slides from the chamber, Analyse the thickness of the film using UV-VIS spectrometer with appropriate methodology learnt from previous semester!