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LAB REPORT

Thin Film Deposition Using Electron Beam Evaporation

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Objective

To Deposit the thin film on the substrate using Electron Beam Evaporation.

Abstract

E-beam evaporation begins with the passage of current through a tungsten filament, which causes joule heating and electron emission. These free electrons are accelerated toward the crucible containing the material to be deposited by applying a high voltage between the filament and the hearth. When the electrons are concentrated into a single beam by a powerful magnetic field, their energy is transmitted to the deposition material, causing it to evaporate (or sublimate), then deposit onto the substrate.

Keywords: Electron Beam, Physical Vapour Deposition,Thin Film.

Contents

1 Theory and Introduction

Before proceeding to the procedure me will get an idea about the concept behind the experiment.

1.1 Principle behind electron beam evaporation

- When wire is heated to red hot, it emits e^- due to thermo-ionic emission, then e^- travels through small orifice. An e^- beam is bend to 27^0 through magnetic field (Lorentz force) and K.E. of e^- beam is converted to heat.

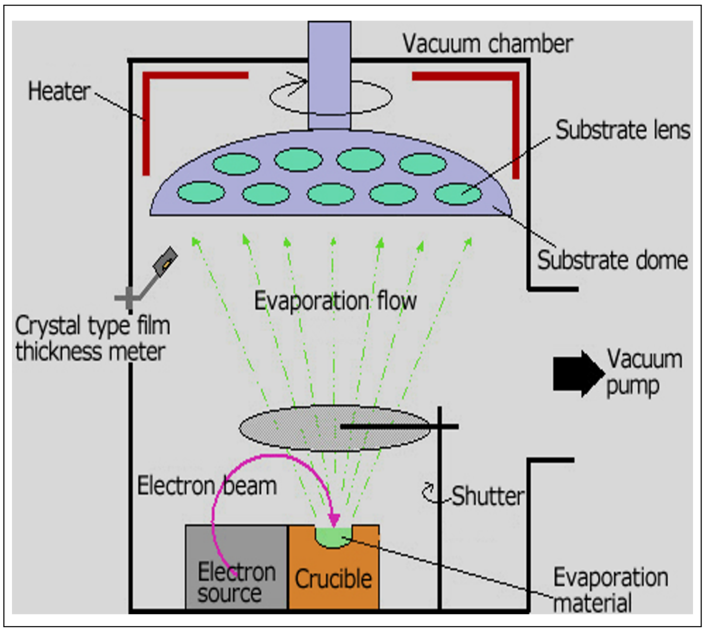

Figure 1: Schematic diagram of peicnciple of electron beam evaporation

- Target material (coating) is bombarded with e-beam from a charged tungsten filament to evaporate and convert it into the vapour for deposition on the substrate.

1.2 Thin film

- A thin layer of material deposited on a substrate that can be a metal, plastic, semiconductor or ceramic base.
- It's thickness varies from nm to μm.
- Conductive or Non-Conductive.
- Eg: Coating on magnetic magnetic discs, Hard coating on machine tools, anti reflection layer on glasses etc.

1.3 Thin Film Deposition

It can be deposited by two processes:

- Physical Vapour Deposition
- Chemical Vapour Deposition

1.4 Rotary Pump

- Rotary vane vacuum pump in a kind of oil seal mechanical vacuum pump.
- It can be used alone or as a backing pump for other high vacuum pumps or ultra high vacuum pumps.

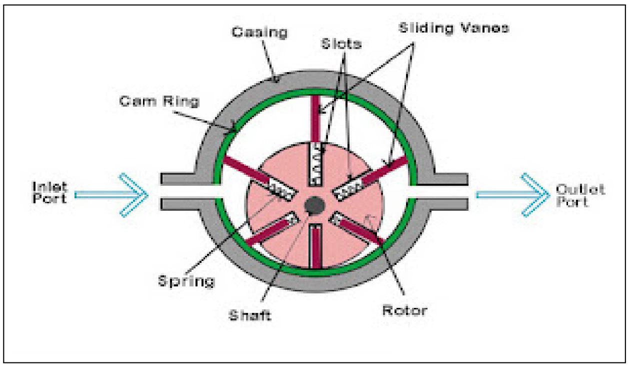

Figure 2: Schematic diagram of rotary pump

- Rotary vane pump can pump the dry out of the sealed container.
- It can also pump a certain amount of condensable gas out if chamber is attached.

1.5 Diffusion Pump

- The diffusion uses the vapor of a bailing fluid to capture air molecules.
- Using Coolant, we condensed the oil vapour.

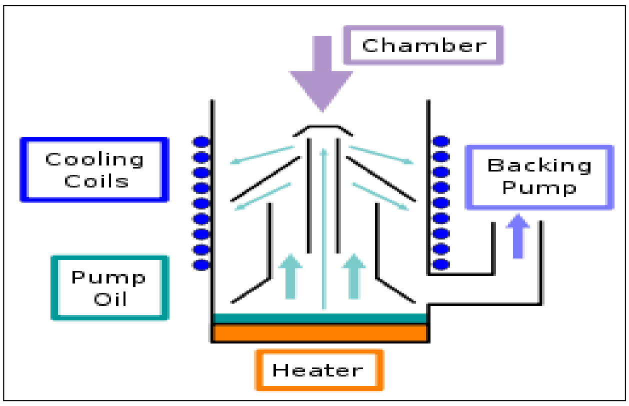

Figure 3: Schematic diagram of diffusion pump

- Then via suction of Condensed oil with air molecules goes off to pump.

2 Experimental Setup

Schematic diagram is given in Figure 4, at the bottom of the chamber we have to keep the target material for heating. At the top of the chamber substrate is fixed where we have to deposit the thin film.

For thickness measurement for thin film, on the left side there is movable shield, from which we can control the deposition thickness.Roughing valve joins chamber to rotary pump and backing valve joins chamber to diffusion pump. which help to create the vacuum.

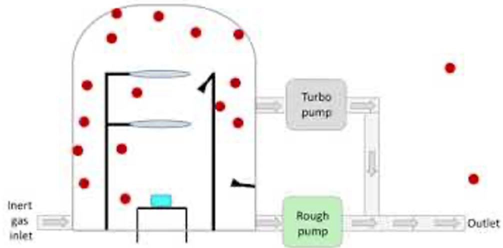

Figure 4: Schematic for deposition of thin films by EB

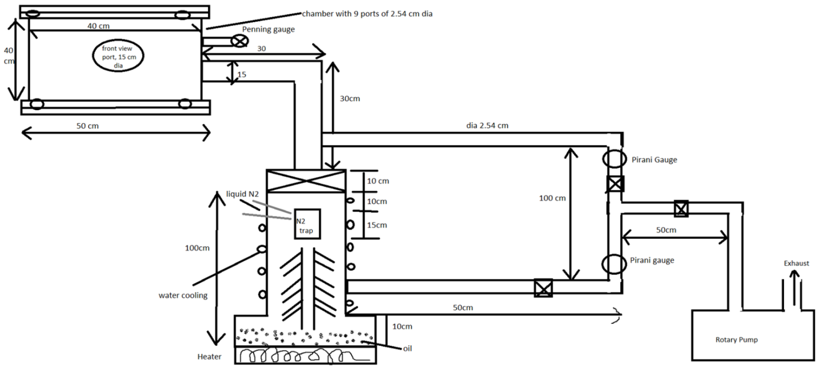

Figure 5: Typical Vacuum System

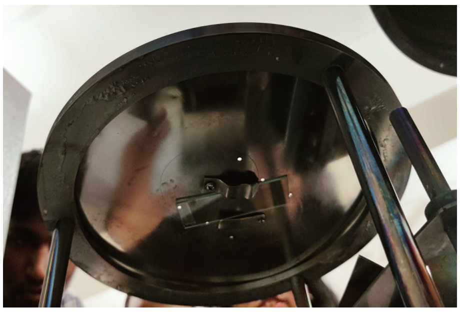

Figure 6: Glass Substrate

Figure 7: Vacuum Chamber

3 Procedure

3.1 Experimental parameters

- Input voltage : 5-6 kV
- Current: 100 mA
- Deposition rate: 1.55 μm/hr

3.2 Pumping The System

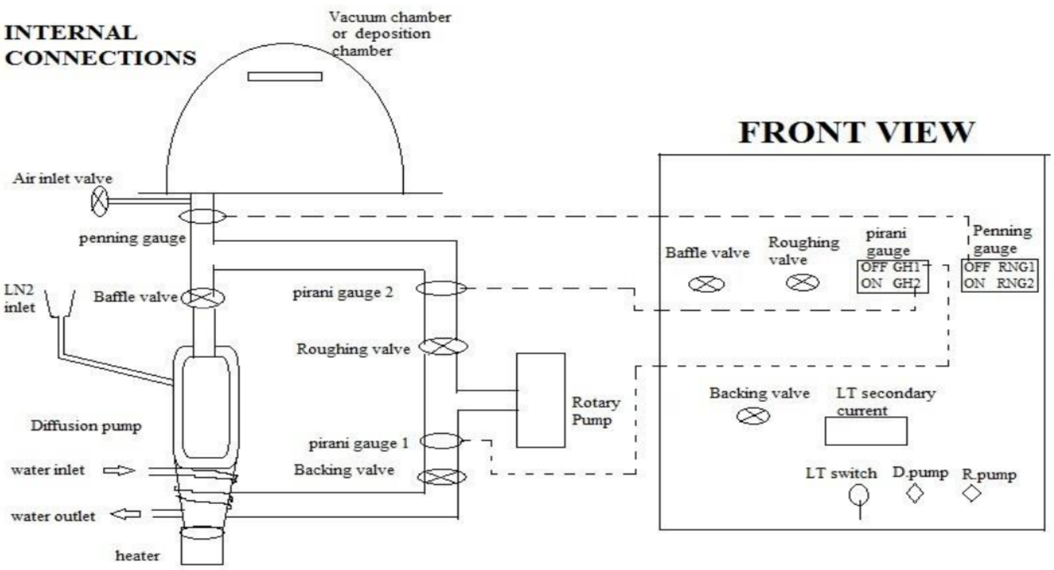

Figure 8: Schematic diagram of Thin Film Coating Unit

- Clean the chamber properly with ethanol.
- Close the bell chamber and close the air admittance valve.
- Switch on the rotary pump and turn on the roughing valve.
- The reading is shown by GH2 of the pirani gauge, wait till pressure reach to 1x10^{-2} mber.
- Tum on the backing valve and close to roughing vare. check the reading in GHZ of Pirani gauge wait till pressure reaches below 1x10^{-2} mbar.
- Now switch ON diffusion pump, wait for 20 min for the oil to get heated up and Pour liquid N_2
- wait for 45 - 60 min for the vacuum to reach 1x10^{-6} mbor, on the penning gauge.

3.3 Deposition of Thin Film

- Clean the chamber properly
- Switch ON the mains (HTCB) & get the voltage to 5-6KV.
- ON the LTCB slowly adjust the current to 100mA. Hill the filament glow (orange-red)
- The sample slowly changes color & becomes red hot indicating that it has melted.
- Check in though the peep hole to monitor the deposition.

3.4 Shut Down the Vacuum System

- Ensure the HIVAC is closed.
- Close the backing valve, Turn OFF Rotary Pump.
- Wait for five min, and near water inlet to DTM and transfer off the water pump.
- Turn OFF the mains.

3.5 Analysis of the thickness of the film

- After taking out (carefully) the covered glass slides from the chamber, weigh them (i.e. W1, W2).
- Account for the thickness of the film by evaluating the weights difference with surface area.

4 Parameters

- Target Metal - Sn
- substrate - glass
- Voltage 5-6 Kv
- Current - 100 mA
- Pressure - 10 torr
- Filoment - W (tungston)
- Gauges- Pirani, Penning
- Machine - Single Pocket Machine

5 Advantages

- No substrate heating
- Deposition rate is so fast
- Uniform film thickness with high surface area.
- It can achieve on temp $\geq 300\ ^0$C.
- Damage to this film is small
- Easy to industrialize.

6 Limitations

- Productions of vacuum chamber takes major. time
- Presence air contaminant can reduce film quality.
- Non- Conductive material can not be coated
- It can generate X-rays.
- Small filament size limits the deposition thickness.