Indian Institute of Technology
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Lab Report

Thin Film Deposition Using DC Magnetron Sputtering

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Objective

To Deposit the thin film on the substrate using DC Megnetron Sputtering.

Abstract

Sputter deposition is a physical vapour deposition (PVD) process used to deposit thin films. With its benefits of simple equipment, simple control, a broad coating area, and high adhesion, the general sputtering method may be used to create a variety of materials including metals, semiconductors, insulators etc.Thin film growth is dominated by magnetron sputtering because it produces a huge number of thin films at a low cost and reasonably high purity. On a "substrate" like a silicon wafer, material is ejected from a "target" that serves as a source in this process.

Keywords: DC Megnetron Sputtering, Physical Vapour Deposition,Thin Film Deposition.

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 DC Magnetron Sputtering

The process of incident particles colliding with targets is known as magnetron sputtering. It is vital to efficiently boost the gas's ionisation rate because high-speed sputtering is carried out at low pressure. The incident particle experiences a difficult scattering process in the target, collides with an atom there, and transfers some of its momentum to the atom. The atom then collides with further atoms in the target, creating a cascade process. Some target atoms near the surface obtain enough momentum during this cascade to move away from the target and are sputtered out of it.

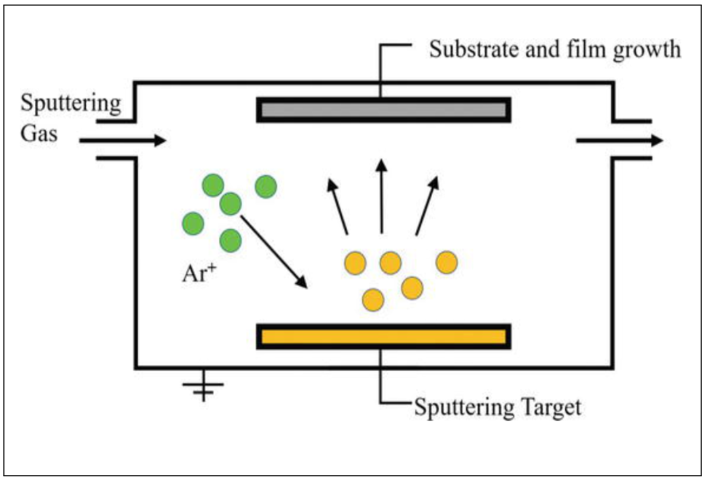

Figure 1: Schematic diagram of peicnciple of electron beam evaporation

By applying a magnetic field to the target cathode's surface and using the magnetic field's restrictions on the charged particles to accelerate the sputtering rate, magnetron sputtering raises the plasma density.

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.

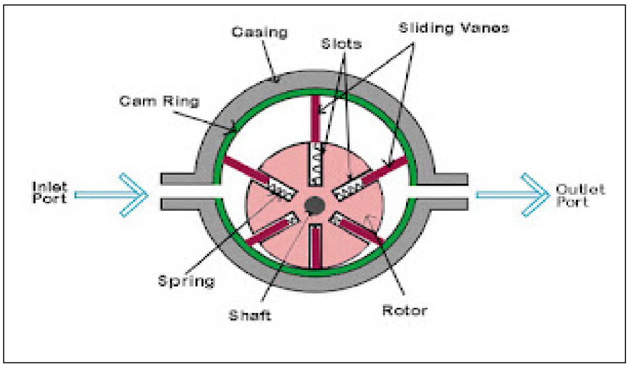

Figure 2: Schematic diagram of rotary pump

- 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.

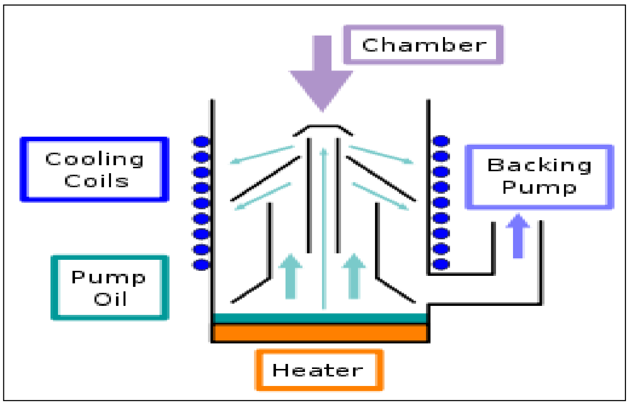

Figure 3: Schematic diagram of diffusion pump

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

2 Experimental Setup

When the HiVac valve is ON, Then there will be potential difference. High ionization will create and Ar^+ and e^- will be there.Plasma will be created using potential difference and Ar^+ hits to cathode and and create sputtering to target material. 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.

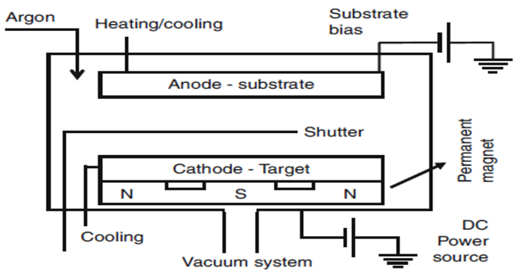

Figure 4: Schematic for deposition of thin films by DC Magnetron Sputtering

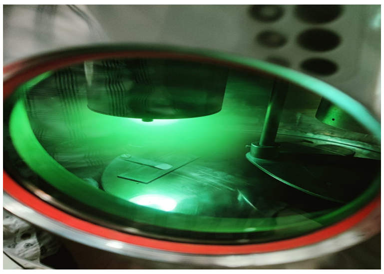

Figure 5: DC Magnetron Sputtering

Figure 6: Vacuum Chamber

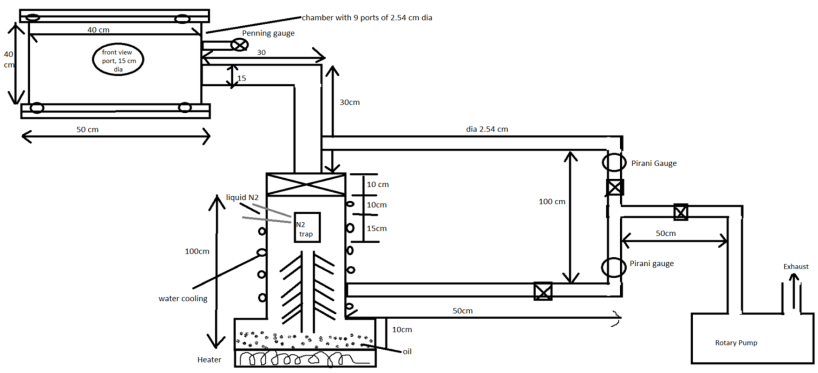

Figure 7: Typical Vacuum System

3 Procedure

3.1 Materials Required

- Target Metal - Copper (Cu)
- Glass Substrate
- Inert Gas - Argon(Ar)
- Vacuum Chamber
- Permanent magnets
- DC Magnetron Sputtering System

3.2 Experimental parameters

- Input voltage : 350 V
- Current: 0.5-0.6 A
- Deposition rate: 1.55 μm/hr

3.3 Pumping The System

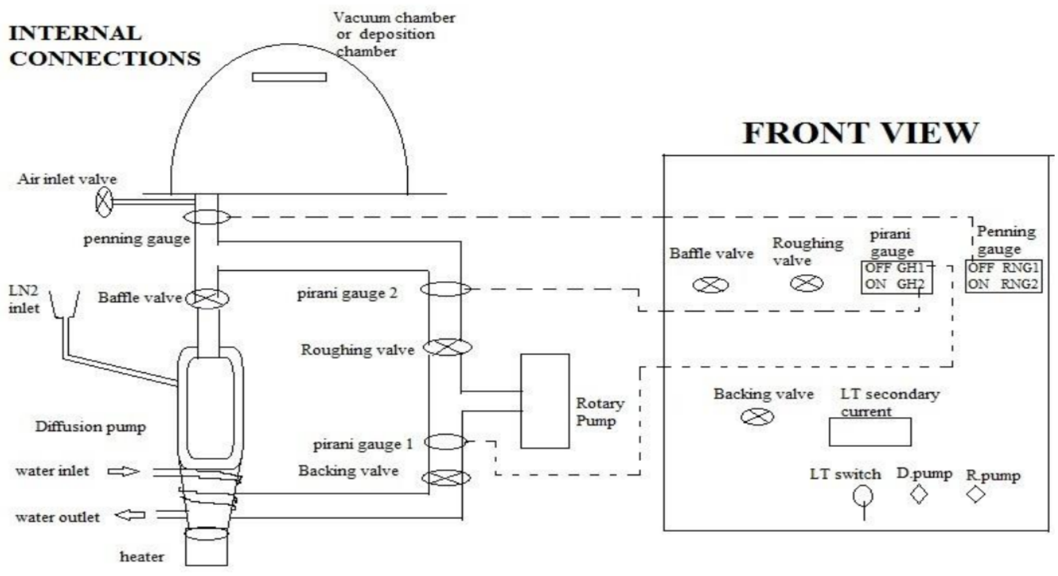

Figure 8: Schematic diagram of Thin Film Coating Unit

- 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 valve. 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^{-5} mbor, Stop the penning gauge.

3.4 Deposition of Thin Film

- Switch ON the inert gas supply using thimble
- Switch ON the power supply & get the voltage to 350 V & current 0.5-0.6 A.
- Guaranteed plasma formation and sputtering starts.
- Wait for the 10 mins to see copper deposition.
- Check in though the peep hole to monitor the deposition.

3.5 Shut Down the Vacuum System

- Ensure the HIVAC is closed.
- Close the backing valve, Turn OFF Rotary Pump.
- Wait for five min to apparatus reach the room temperature.
- Turn OFF the mains.

3.6 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 - Cu
- Substrate - glass
- Voltage - 350 V
- Current - 0.5-0.6 A
- Pressure - 10^{-6} mbar
- Gauges- Pirani, Penning

5 Advantages

- Deposition rate fast , damages to the film is small.
- Well combined thin film on substrate.
- Uniform thickness , large area substrate.
- 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.
- Plasma instability issue.