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LAB REPORT

Thin Film Deposition Using Thermal Evaporation

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Objective

To Deposit the thin film on the substrate using thermal evaporation process.

Abstract

A solid material is heated to a temperature that generates some vapour pressure during thermal evaporation inside a high vacuum chamber. Even a relatively low vapour pressure in the vacuum will be enough to raise a vapour cloud inside the chamber. This material has now evaporated, forming a vapour stream that travels through the chamber and strikes the substrate, adhering to it as a coating or film. The substrate, which can be any of a variety of things including semiconductor wafers, solar cells, optical components, or many other options, is the thing that needs to be coated.

Keywords: Thermal Evaporation, Physical Vapour Deposition,Thin Film.

Contents

Contents **2**

1 Introduction and Concept **3**

2 Experimental Setup **4**

3 Procedure **5**

3.1 Experimental parameters 5
3.2 Pumping The System 5
3.3 DEPOSITION (THIN FILM) 6
3.4 Shut Down the Vacuum System 7
3.5 Analysis of the thickness of the film 7

4 Advantages of thermal evaporator **7**

5 Disdvantages of thermal evaporator **7**

1 Introduction and Concept

Thermal evaporation is one of the commonly used Physical Vapor Deposition (PVD) techniques. This is a type of thin film deposition, a vacuum-based technique for coating various materials' surfaces with pure materials. The coatings, also known as films, can be made of a single material or a combination of materials arranged in layers. Their typical thickness ranges from angstroms to microns. Thermal evaporation techniques can be used to apply compounds like oxides and nitrides as well as pure atomic elements, including both metals and non-metals.

In the Figure 1, the The material is typically found in the bottom of the chamber, frequently in the form of an upright crucible, because it is liquid and heated to its melting point in most Thermal Evaporation procedures. Following this bottom source, the vapour rises, holding the substrates inverted in the proper fixtures at the chamber's top. Thus, in order to obtain their coating, the surfaces intended for coating are directed downward toward the hot source material.

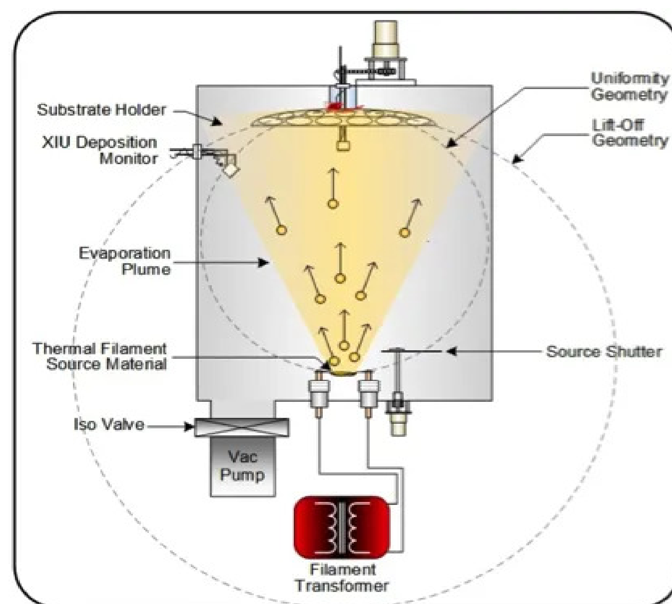

Figure 1: Diagram of Thermal Evaporation Process

To ensure film adhesion and regulate different film properties as needed, actions may need to be taken. To give process engineers the opportunity to obtain desired outcomes for factors like thickness, homogeneity, adhesion strength, stress, grain structure, optical or electrical properties, etc., thermal evaporation system design and processes fortunately allow adjustability of a variety of parameters.

2 Experimental Setup

Schematic diagram is given in Figure 2, 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.

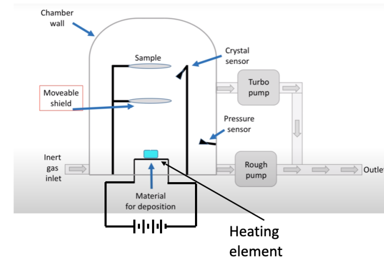

Figure 2: Schematic for deposition of thin films by thermal evaporation

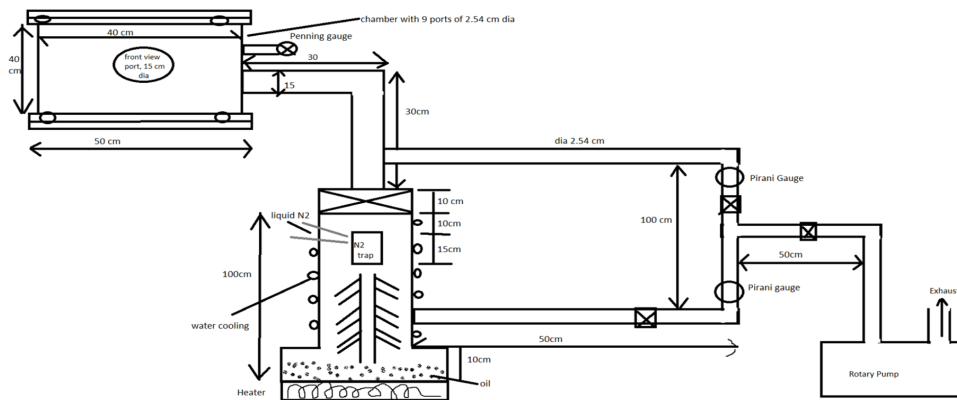

Figure 3: Typical Vacuum System

Figure 4: Target Material

Figure 5: Thermal Evaporation

3 Procedure

3.1 Experimental parameters

- Input voltage : 110 V
- Current: 40-70 A
- Deposition time: 10 – 20 s

3.2 Pumping The System

- Turn the Mains on. Ensure all of the valves are closed (they near clockwise).
- Turn on Rotary pump and look ahead to 2-5 mins. Turn on Pirani gauge and take a look at the vacuum degree in GH1 (it must be round 0.05 mbar).
- Open roughing valve (flip anti-clockwise) to begin roughing (to pump the deposition chamber with the aid of using Rotary pump to get medium vacuum).
- Wait until vacuum falls much less than 0.02 mbar in GH2. Do roughing for approximately 30 minutes.
- Close the roughing valve. (flip clockwise)
- Open backing valve (flip anti-clockwise) to pump DP (Diffusion Pump) chamber.
- Wait until vacuum is much less than 0.01 mbar in GH1.
- 7. Switch ON water pump and ensure water inlet valve to DP is open and water is circulating across the DP chamber. Further, ensure water inlet valve to DTM is closed.

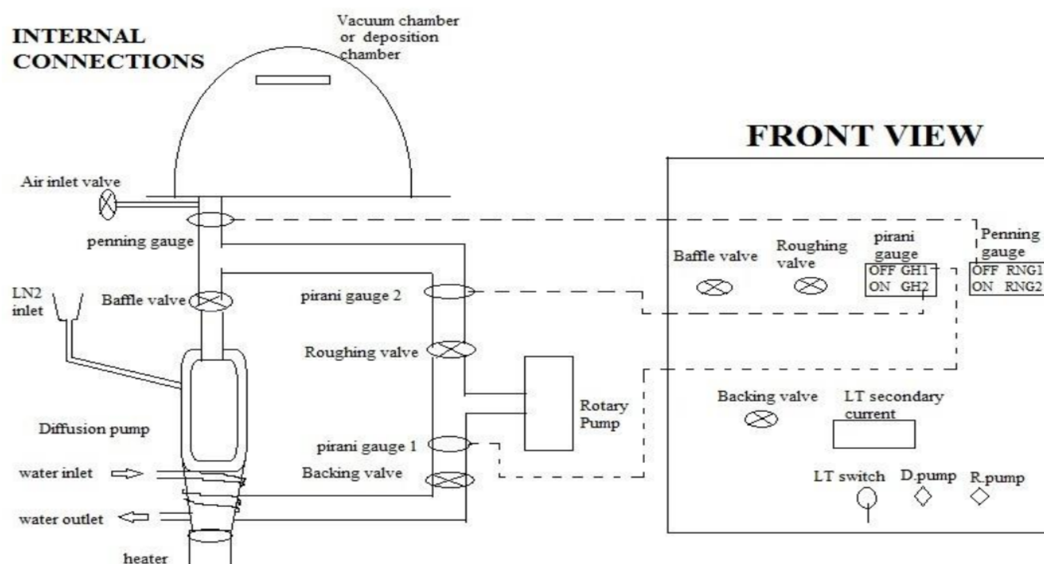

Figure 6: Schematic diagram of Thin Film Coating Unit

- Make positive that roughing valve is CLOSED and backing valve is OPEN.
- Turn at the DP. Wait for approx. 30 min for it to emerge as hot.
- Close backing valve and open roughing valve to make sure that strain interior deposition chamber and DP chamber is nearly identical (0.02 mbar). This may take round 2-3 minutes.
- Close roughing valve and open backing valve again.
- Open BAFFLE (gently, it's a plate!) to pump the deposition chamber with the aid of using DP.
- Pour LN2 withinside the entice thru respective inlet until LN2 spills over at its outlet.
- Wait for 15 minutes. Monitor strain in the deposition chamber in Penning gauge. Wait until strain falls underneath 10^{-5} mbar. DO NOT hold penning gauge ON continuously (specially throughout low vacuum).
- Continue pumping for at the least forty 5 mins and hold tracking the vacuum.

3.3 DEPOSITION (THIN FILM)

- Ensure vacuum in the deposition chamber is much less than 10five mbar the use of penning gauge RNG 2 (otherwise, wait until you attain it OR look at for any leak). Note down the cost of the vacuum in all 3 guages.
- Open the water inlet valve to permit water to flow into thru DTM.
- Turn at the Digital Thickness Monitoring (DTM) unit.
- Input right values of DNT (density in g cm three) and ACI (Acoustic Impedance). Press the corresponding button and press INC or DEC to attain the cost.
- Press STR button to screen thickness and deposition rate.
- Turn on LT MAIN (transfer). Slowly growth present day (with the aid of using rotating the variable; (variable voltage knob) in primary to attain favored deposition rate (hold tracking the mild because of heating of the filament (in the vacuum chamber) .
- Quickly press STR in thickness screen again (to begin from 0 thickness). You would additionally have a look at a drop within side the vacuum throughout this process
- After attaining favored thickness. Decrease present day slowly. Press STP button in thickness screen to forestall tracking. Note the values withinside the DTM at this level and on the give up of the test. circulating across the DP chamber. Further, ensure water inlet valve to DTM is closed.
- Turn off the LT transfer.
- If you need to test the pleasant of the coating immediately (at the identical day), you ought to bypass subsequent steps and comply with the stairs withinside the sections V and VI (Vent the chamber and evaluation of the movie). It is recommended to do subsequent day with a clean start.

- Turn OFF the DTM (thickness screen) unit.
- Close BAFFLE and flip OFF Penning Gauge, when you have saved it ON.

3.4 Shut Down the Vacuum System

- Ensure the BAFFLE is closed.
- Turn OFF DP. Keep doing backing (i.e. backing valve open) and permit water flowing through DP in addition to DTM and wait until the DP is cooled to room temperature (approximately 30 mins).
- 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 Advantages of thermal evaporator

- No substrate heating
- Films can be deposited at high rates ($e.g., 0.5m/min$)
- Low energy atoms (0.1 ev) leave little surface damage
- Little residual gas and impurity incorporation due to high vacuum conditions
- Usually consists of multiple samples (cu, Au, Ni etc)

5 Disdvantages of thermal evaporator

- Limited to the low melting point metals
- Small filament size limit the deposition thickness
- Cr coated substrate is required for gold thin film deposition
  - Weak adhesion between substrate and gold atoms