MME 4021 MATERIALS PROCESSING LABORATORY

Experiment 6 - Spin coating / dip coating

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1. Subject: Spin Coating Technique

2. Objective: The purpose of this laboratory session is to introduce students to the spin coating technique for depositing thin films onto substrates. Through this hands-on experience, students will understand the principles behind spin coating, and optimizing key parameters.

3. Theory

3.1. Spin Coating Overview

Spin coating is a simple process for rapidly depositing thin coatings onto relatively flat substrates. The substrate to be covered is held by some rotatable fixture (often using a vacuum to clamp the substrate in place) and the coating solution is dispensed onto the surface; the action of spinning causes the solution to spread out and leave behind a very uniform coating of the chosen material on the surface of the substrate. After spinning, the excess solution is removed, leaving behind a deposited film. The spin coating process has been studied extensively in the past and much is known about factors that control coating deposition and the final thickness of the deposit that results [1]

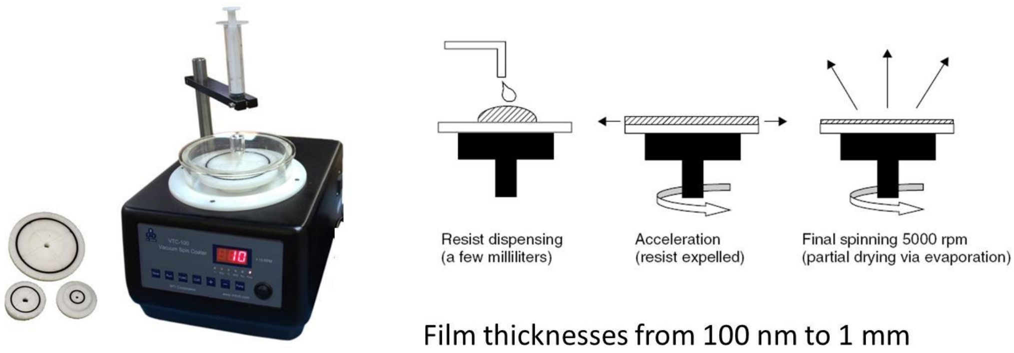


Figure 1. Spin coating device and schematic view of the spin coating process

3.2. Key Parameters

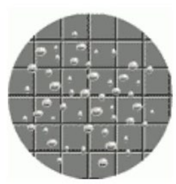
Spin Speed: The rotational speed of the spin coater affects film thickness and uniformity. Higher speeds generally result in thinner films.

Spin Time: The duration of spinning influences the amount of solvent evaporation and, consequently, the final film properties.

Coating Solution: The composition and concentration of the coating solution play a crucial role in determining film characteristics.

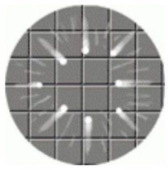
3.3. Problems

Spin Speed



- Air bubbles in dispensed fluid (resin)
- Dispense tip is cut unevenly or has burrs or defects.

Comets, streaks, or flares



- Fluid velocity (dispense rate) is too high.
- The spin bowl exhaust rate is too high.
- The spin speed and acceleration setting are too high.
- Particles exist on the substrate surface before dispensing.
- Fluid is not being dispensed at the center of the substrate surface.

Swirl pattern

- The spin bowl exhaust rate is too high.
- Fluid is striking the substrate surface off-center
- The spin speed and acceleration setting are too high, spin time too short

Uncoated areas

- Insufficient dispense volume.

Pinholes

- Air bubbles
- Particles in fluid
- Particles exist on the substrate surface before dispensing.

4. Applications

Semiconductor Fabrication: Spin coating is widely used in the semiconductor industry for applications such as photoresist coating. It helps in creating thin, uniform layers on semiconductor wafers before photolithography and etching processes.

Photovoltaics: In the fabrication of solar cells, spin coating is used to apply thin films of materials like perovskites or organic photovoltaic materials onto glass or flexible substrates

Organic Electronics: Organic thin-film transistors (OTFTs) and organic light-emitting diodes (OLEDs) often utilize spin coating to deposit organic semiconductor materials onto substrates.

5. Procedure

1. Wear appropriate personal protective equipment, including gloves and safety goggles.
2. Ensure the work area is well-ventilated or carry out the experiment in a fume hood.
3. Clean the substrates (e.g., silicon wafers or glass slides) to be used for film deposition.
4. Prepare the coating solution according to the specifications provided.
5. Ensure the solution is well-mixed and free of impurities.
6. Place the cleaned substrate onto the spin coater chuck, ensuring it is properly centered.
7. Dispense a small amount of the coating solution onto the center of the substrate.
8. Close the lid of the spin coater.
9. Set the spin parameters (speed and time).
10. Start the spin coater and monitor the spreading of the solution on the substrate.
11. Allow the coated substrate to undergo a brief period of evaporation to remove the solvent.
12. Repeat the spin coating process if necessary.
13. Maintain and clean the machine.

1. Subject: Dip Coating Technique

2. Objective: The purpose of this laboratory session is to introduce students to the spin coating technique for depositing thin films onto substrates. Through this hands-on experience, students will understand the principles behind dip coating, and optimizing key parameters.

3. Theory

3.1. Dip Coating Overview:

Dip coating is a widely employed method for depositing thin films by immersing a substrate into a liquid coating solution and then withdrawing it at a controlled rate. In this method, the substrate is normally withdrawn vertically from a desired coating solution, which causes a complex process involving gravitational draining with concurrent drying and continued condensation reactions. The formation of thin films occurs through solvent evaporation (mainly ethanol and water), which concentrates non-volatile species in the system, then leading to aggregation and gelation. It is the oldest and the most widely used deposition technique in the industry because it is easy to use, high coating quality, flexibility, and cost efficiency [2–4]

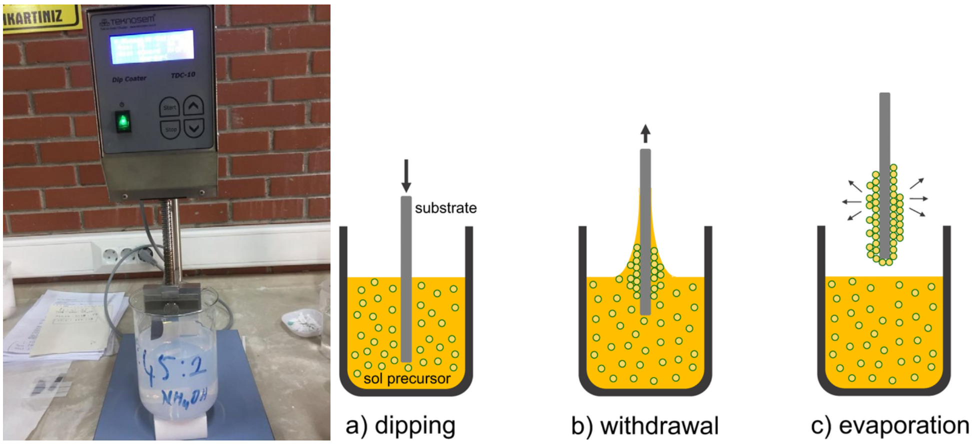


Figure 2. Dip coating device and schematic view of the dip coating process

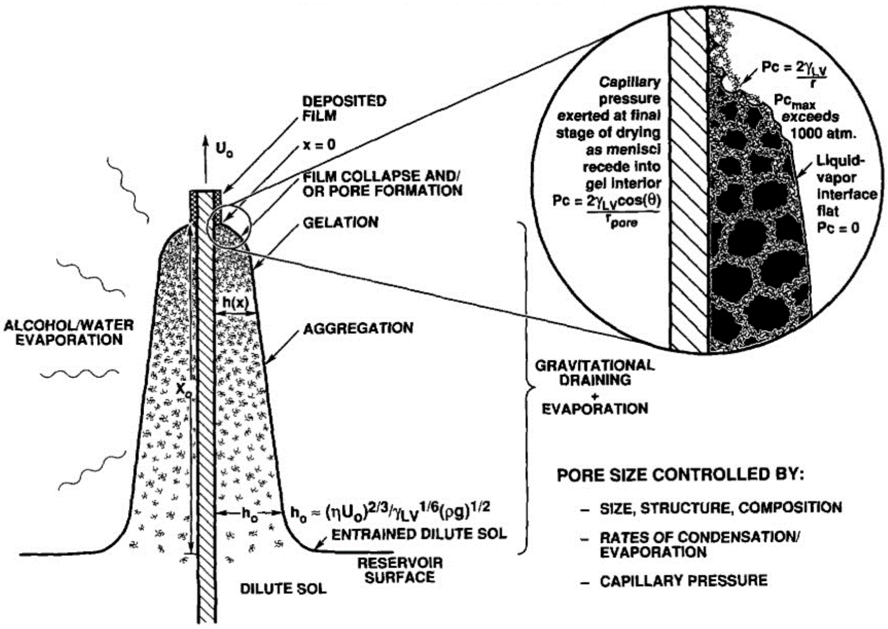


Figure 3. Schematic of the steady-state dip-coating process, showing the sequential stages of structural development

3.2. Key Parameters

Viscosity of Coating Material: Determines coating thickness and material flow.

Withdrawal Speed: Affects coating thickness and uniformity during object removal.

Immersion Time: Influences coating thickness; duration of object immersion.

Coating Material Temperature: Affects material viscosity and solvent evaporation rate.

Ambient Conditions: Affects solvent evaporation rate.

4. Applications

Automotive Components: Automotive parts, such as springs, brake components, and fasteners, often undergo dip coating for corrosion resistance, lubrication, and to improve their appearance.

Corrosion Protection: Dip coating is utilized to apply protective coatings on metal objects to prevent corrosion. The coating material can be a corrosion-resistant paint or a specialized coating.

Medical Devices: Implants and medical instruments can be dip-coated with biocompatible materials to enhance their performance, durability, and reduce the risk of adverse reactions within the body.

5. Procedure

1. Wear appropriate personal protective equipment, including gloves and safety goggles.
2. Ensure the work area is well-ventilated or carry out the experiment in a fume hood.
3. Clean the substrates (e.g., glass slides) to be used for film deposition.
4. Prepare the coating solution with the desired material and concentration.
5. Ensure the solution is well-mixed and free of impurities.
6. Attach the clean substrate to the dip coater arm, ensuring it is securely fastened.
7. Submerge the substrate into the coating solution at a controlled speed.
8. Allow the substrate to dwell in the solution for a specified duration.
9. Lift the substrate from the solution at a controlled rate.
10. Ensure a smooth and uniform withdrawal to achieve an even coating.
11. Allow the coated substrate to dry either in the air or using controlled drying methods.
12. Repeat the dip coating process if necessary.
13. Maintain and clean the machine.

References

[1] Hench LL, Fielder E. Biological Gel-Glasses. Sol-Gel Technol. Glas. Prod. Users. 2004.

[2] Brinker CJ, Hurd A, Brinker CJ, et al. Fundamentals of dip-coating To cite this version : HAL Id : jpa-00249179. 1994;4:1231–1242.

[3] McDonagh C, Sheridan F, Butler T, et al. Characterisation of sol-gel-derived silica films. J Non Cryst Solids. 1996;194:72–77.

[4] Schneller T, Waser R, Kosec M, et al. Chemical solution deposition of functional oxide thin films. Chem. Solut. Depos. Funct. Oxide Thin Film. Springer-Verlag Wien; 2013.