Dip Coating SiO2 on Si & Si/SiO2/W

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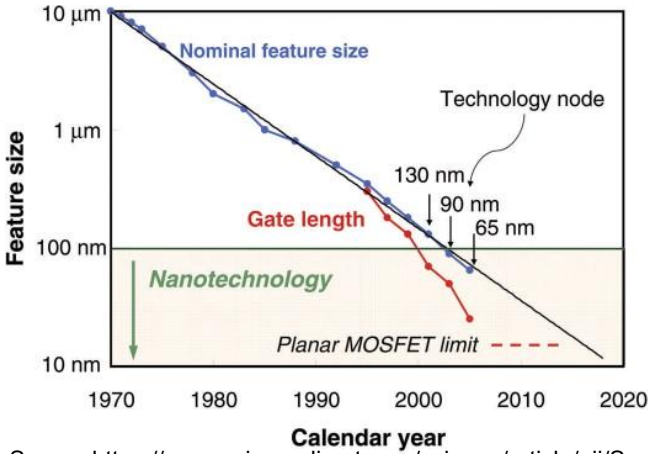
- Objective/Goal
- What is dip coating?
- Challenges with dip coating
- Model used to obtain properties of the graph: ellipsometry
- Details of tools used
- Recipe for dip coating
- Obtained data and results
- Conclusion

Bigger picture

- Today, machine learning and neural networks based technology is used in almost every sector.
- We have reached the possible limit to feature size of a transistor
- Conventional CPUs and GPUs are inefficient for computing complex neural networks.
- RRams is a non-volatile technology and can do complex computations very efficiently
- RRam fabricated using thin film scales down the operational power from Volts to millivolt.
- Fabricating RRams with thin film is a current challenge to researchers.



Source:https://www.sciencedirect.com/science/article/pii/S1369702106715395

Objective

Device Fabrication

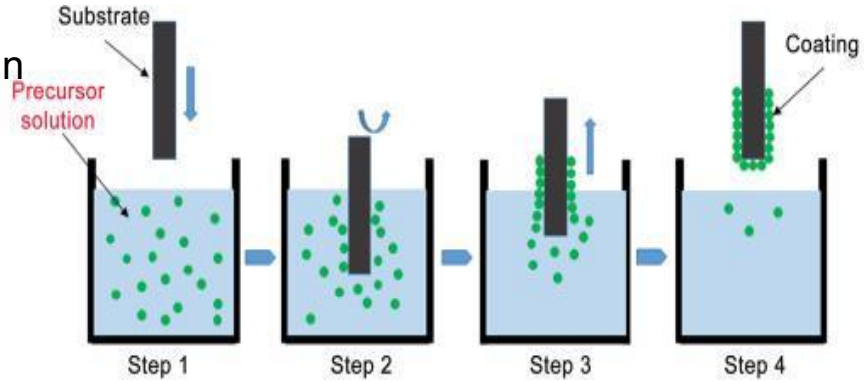
- Use Dip Coating method to deposit SiO2 layer
- Find optimal parameters for obtaining thin layer that can be further use as a device.

Structural characterization

- Study the structural and surface morphology, thickness of the layer deposited.
- Homogeneity, porosity of the film
- Optical properties of the SiO2 deposited
- Conclude and compare the results with other techniques

Dip coating process

- Dip coating is a gel based deposition technique
- To obtain a film, substrate is dipped and removed in a precursor solution
- The thickness of the film controlled by
  - Withdrawal speed
  - Chamber temperature
  - Evaporation rate
  - Viscosity of precursor
- The substrate is annealed afterwards in presence of oxygen to scale the oxide layer as per requirement



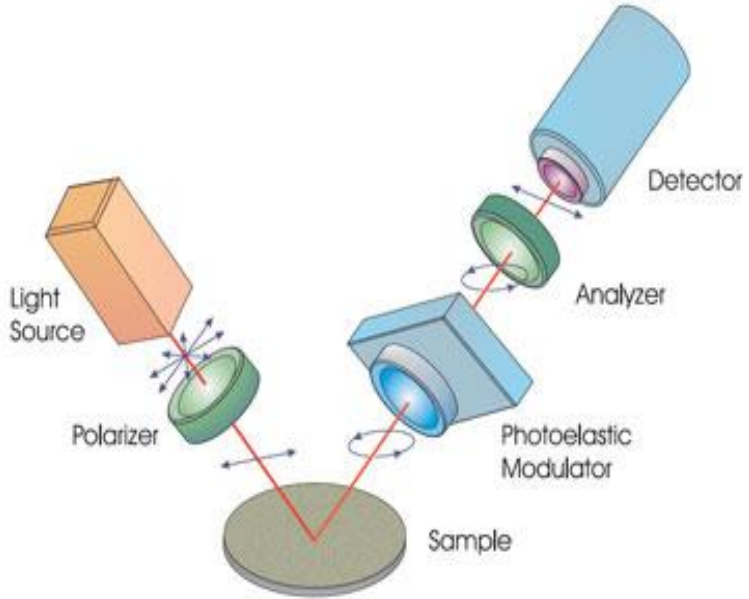
Source: https://www.sciencedirect.com/topics/engineering/dip-coating

Challanges with dip coating

- Withdrawal speed
- Volume of the dip coating container
- Chamber temperature
- Correct amount of Et-OH/2-propanol in the precursor solution.

Ellipsometry

- Ellipsometry is optical technique that is used for analysing the properties of the layer.
- An light beam is reflected from the surface of sample and analysed at other end to see change happened due to sample.
- Ellipsometry can give information on:
  - Optical constants
  - Film thickness
  - Porosity
  - Roughness
  - Other properties associated with change in optical response.



Source:https://www.azom.com/article.aspx?ArticleID=3755

Images of tools used

Ellipsometer

Dip coater

The Sol Composition

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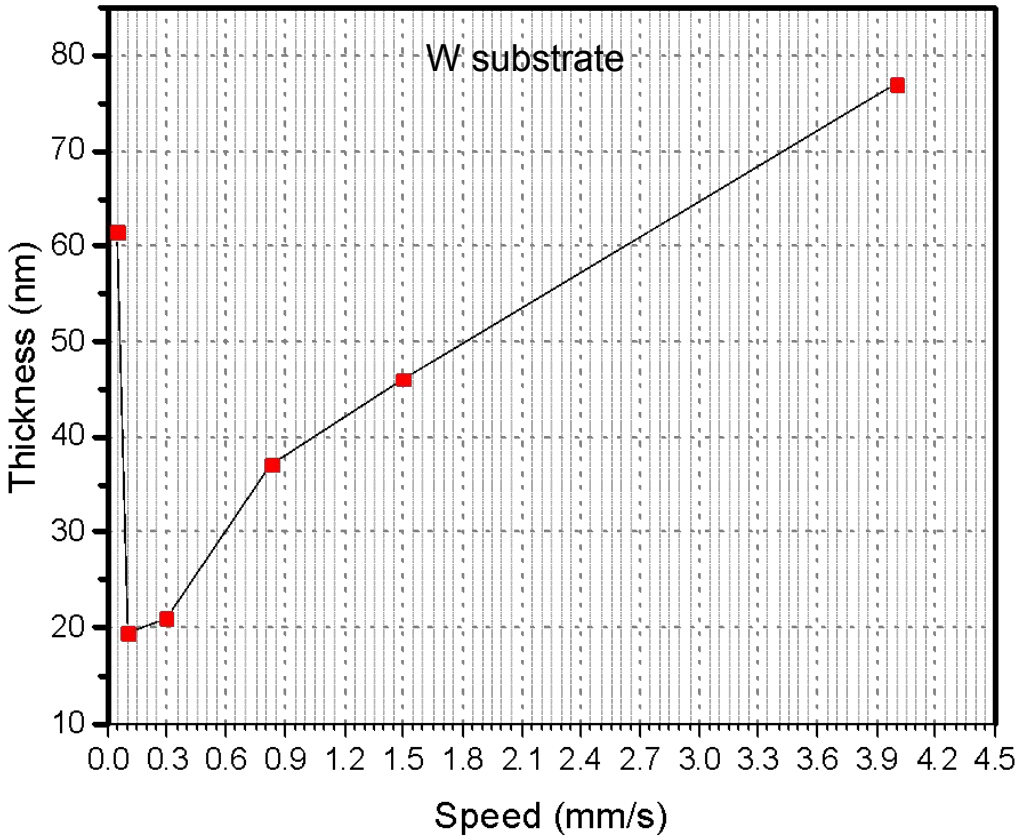
Recipe:

Molar ratio	TEOS/2-Propanol/HCL/H2O : 1/42/4/0.006
Sol Composition	56.3604ml TEOS + 91.505ml 2-propanol + 0.064ml HCL + 2.0526 H2O
Stirring time	90 mins
Temperature	80°C

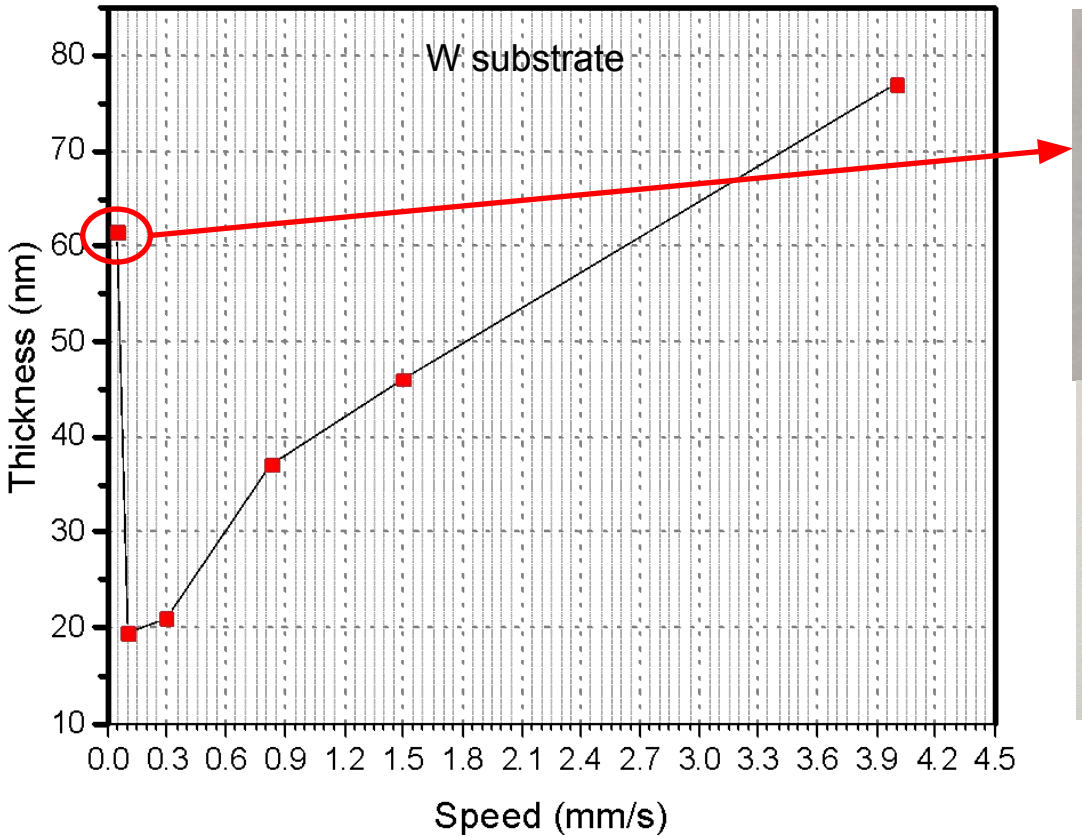
Solution for Dip Coating	5ml Sol(The sol was directly used)
Diluted solution	5ml Sol + 2ml 2-Propanol

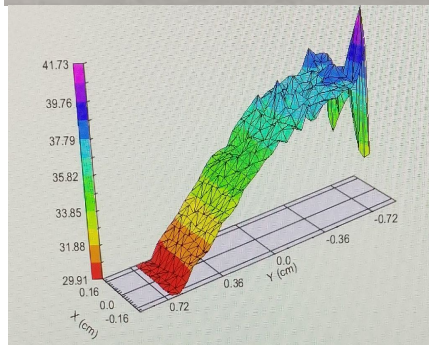
Dipcoating at ambient chamber temperature



- Thinner film was obtained at lower speeds
- Trend was obtained for higher and lower speeds

Dipcoating at ambient chamber temperature



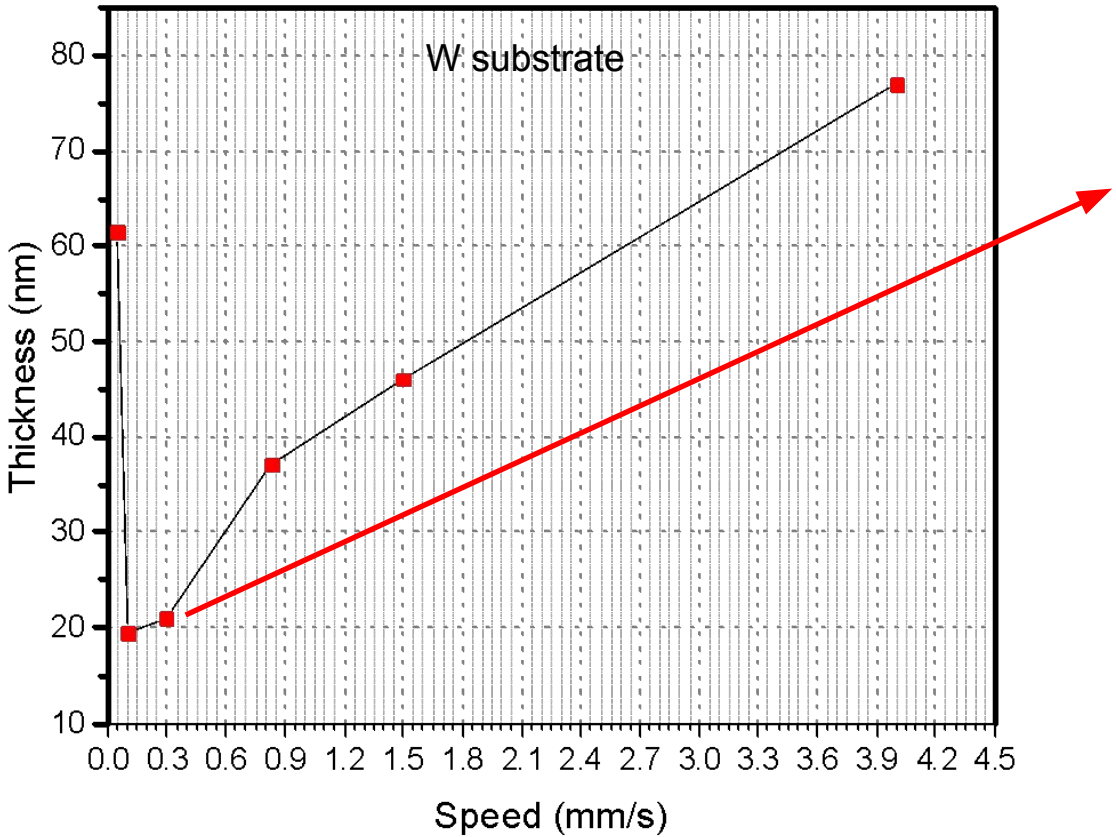


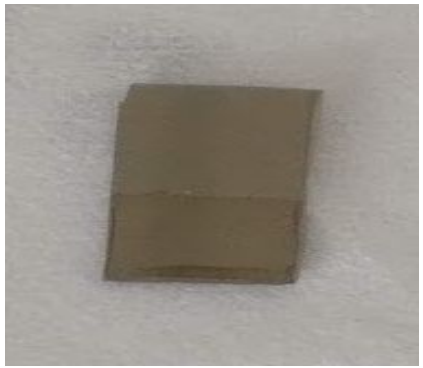
* Gradient at 0.05 mm/s

Thickness map

A gradient was obtained when moved away from center on both sides.

Dipcoating at ambient chamber temperature





Edge effect

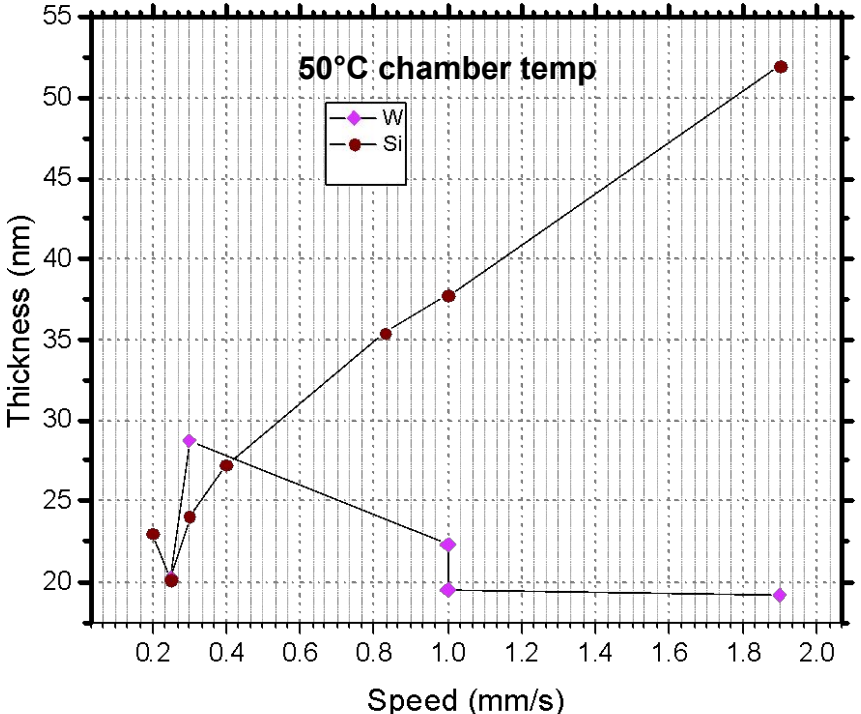
- Thin film was obtained but there was an edge effect at lower end of the coating.

Speed vs Thickness comparison

To eliminate the edge effect, chamber temperature was increased

With **50°C** chamber temperature

W and Si substrate:



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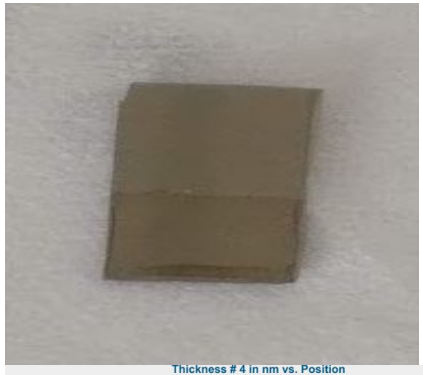
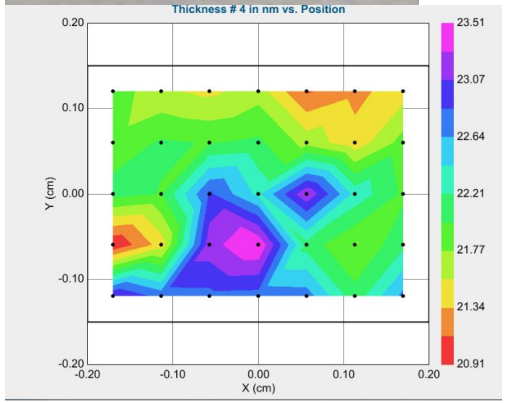


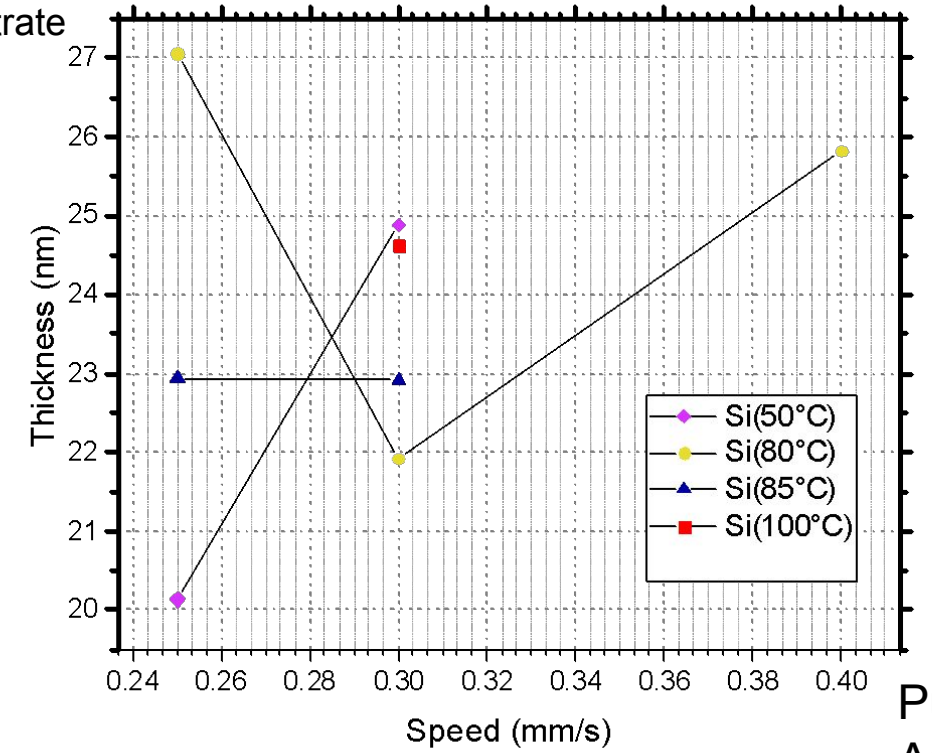
Edge effect

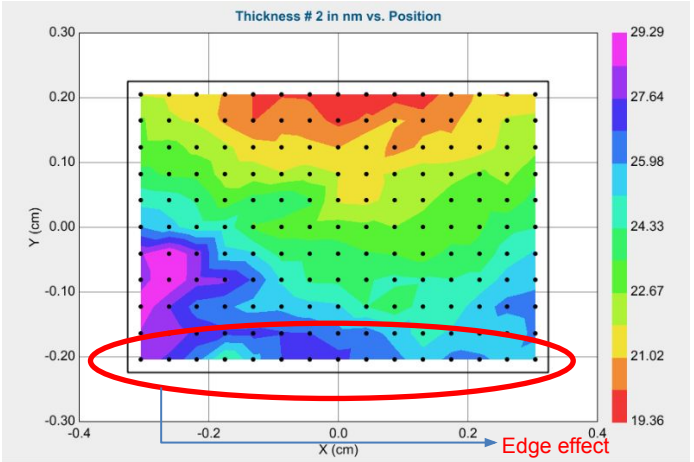


Si substrate: 0.25mm/s
Edge effect still there

Further, an attempt was done to increase the temperature for eliminating the edge effect

Si substrate





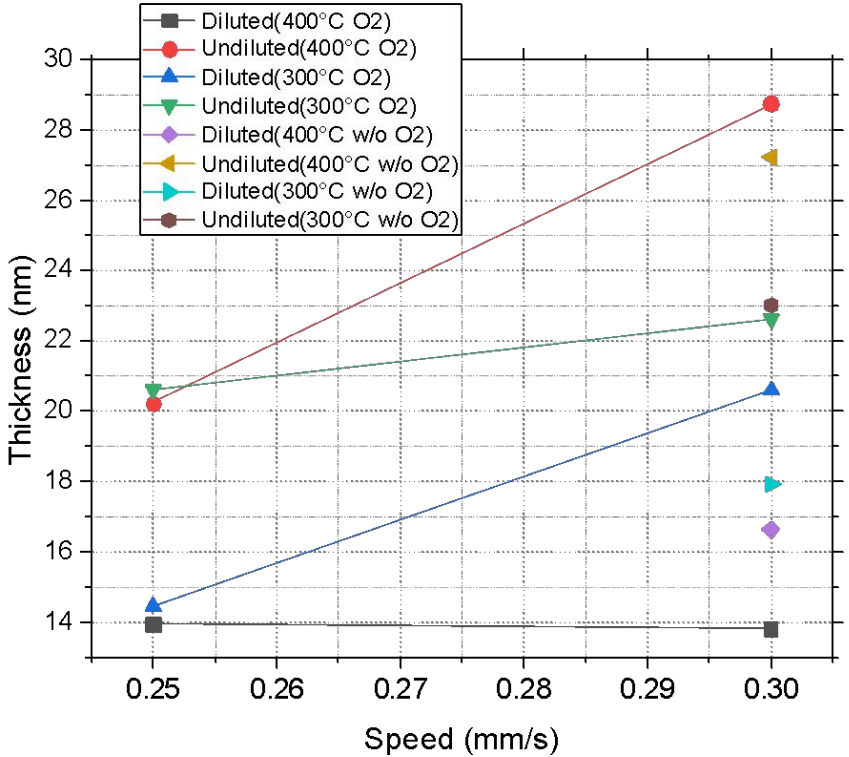
At 50°C, 0.25mm/s

Put optical image
And say map is outside edge

*

The sol was diluted with isopropanol, to reduce the edge effect.

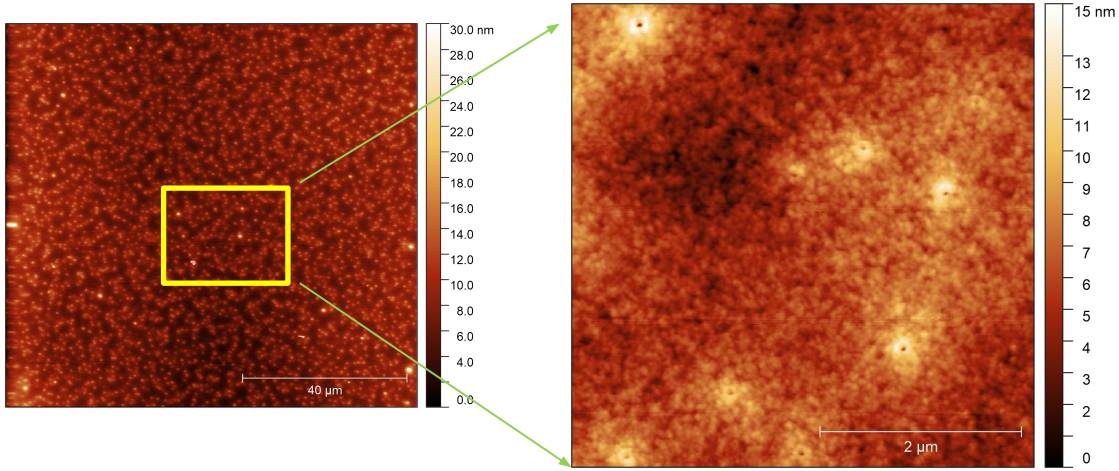
W substrate



AFM was performed to see how the surface looks

S7-15: W substrate 0.25mm/s withdrawal speed, 50°C chamber temperature

- Surface with less pinholes, although we can see peaks upto 15nm height



AFM

Conclusion

Deposition:

- Dip coating is cheap and easy method for depositing thin films
- Less efficient in compare to other depositing techniques
- Desired thickness can be achieved by tweaking parameters like speed, temperature,etc

Structural Characterisation

- Ellipsometry
  - It is great tool to determine thickness, roughness and density of the film.
  - However, hard to fit some models of samples with impurities.
- AFM
  - Great tool for checking surface roughness and surface uniformity

Thank You for your time

Questions???