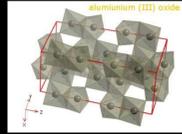


Aluminum Oxide Thin Film Synthesis and Contact Angle Analysis



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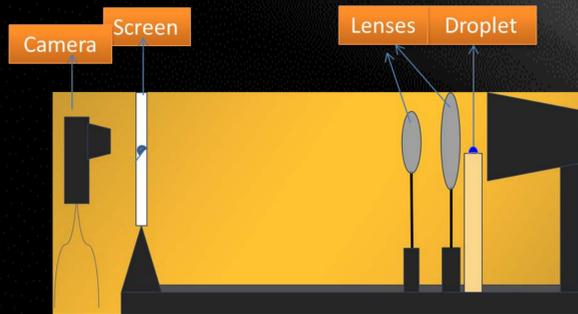
Purpose: The purpose of this experiment was to create Aluminum Oxide thin films, and to observe the different contact angles of silicon with different amounts of Aluminum Oxide thin films grown on them. The contact angles were compared and contrasted

Fig. 1: Aluminum Oxide Structure

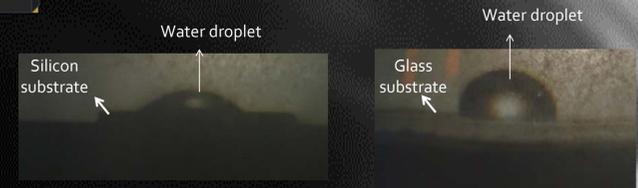
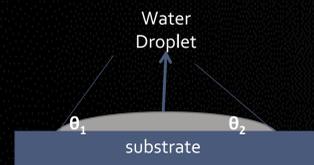
Introduction

- Aluminum Oxide
 - Chemical compound with default formula of Al_2O_3 . It has a band gap of 7.4 eV, making it an insulator.
 - Aluminum Oxide can be found in different forms, such as pellets, powder, tablets, etc.
 - Aluminum oxide can either be Alumina, synthetic Aluminum Oxide, or Corundum, natural Aluminum Oxide.
 - Aluminum Oxide has characteristics of both a covalent and an ionic bond. The reason it is seen as ionic is because it has properties such as having a high melting point of $2072^\circ C$; it is seen as covalent because it has a low solubility as with a good number of covalent compounds.
 - It is amphoteric, meaning it acts like an acid and a base.
 - Aluminum Oxide has numerous phases such as gamma, beta and alpha phases
 - Aluminum Oxide can be synthesized using Atomic Layer Deposition (ALD).
 - ALD is a type of Chemical Vapor Deposition (CVD). ALD is technology used in the synthesis of thin films.
 - ALD is used in Aluminum Oxide synthesis because it is very precise, using the nanometer scale, and can make films as small as 0.1 nm.
 - It is very accurate due to the digital-like growth of the films.
 - ALD is also pinhole free, which aids in the ceramic uses of Aluminum Oxide due to the fact that one doesn't have to worry about Al_2O_3 having small holes when being used as ceramics.
 - The temperature range for ALD is between $50^\circ C$ and $500^\circ C$.
- Corundum:
 - Natural Aluminum Oxide, Corundum, is used for things such as polishing metal, cutting optic glass, sandpaper, etc.
 - Second hardest natural compound, after the diamond.
 - Naturally clear, but can come in different colors due to the presence of other compounds.
- Alumina
 - The synthetic Aluminum Oxide, Alumina, has a big use in ceramics.
 - used for wear pads, seal rings, high temperature electrical insulators, high voltage insulators, etc.

Experimental – Contact Angle Study



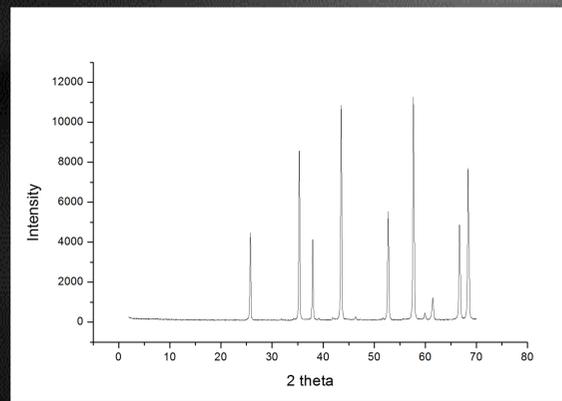
For the contact angle, the set up to the left was used. The light was placed one the far right of the set up. The substrate with the water droplet was placed directly in front of the light on a wood block 18 cm high. The bigger lens was positioned directly in front of the substrate. The smaller lens was put at a distance of 3 inches in front because this is where the image was sharpest. Tracing paper was put at the end of the set up in order to capture the image.. Then, three pictures were taken with the camera of all the substrates used.



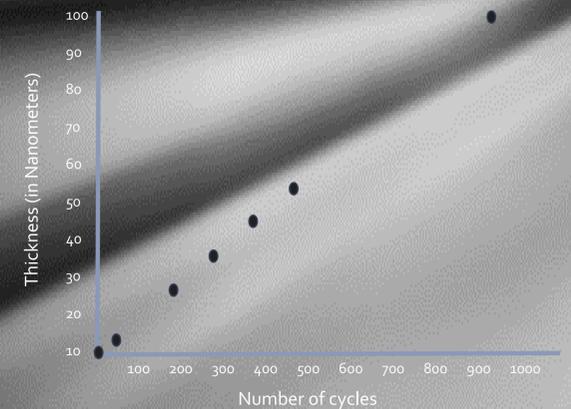
Pictures of water droplets on silicon and glass substrates

Results and Discussion

X-ray diffraction of Al_2O_3 powder



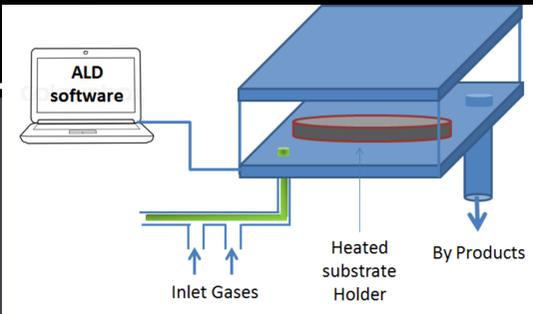
Thickness of aluminum oxide films grown



Experiment:

Thin Film Growth Procedure

Atomic Layer Deposition Chamber similar to the schematic below was used for the thin film growth



- Silicon and Glass substrates were used for this experiment.
- Water vapor and tri-Methyl Aluminum were used as precursors
- Substrates were loaded into the growth chamber and heated to $\sim 250^\circ C$, then the precursors were introduced

Contact Angles for droplets on Si Substrates

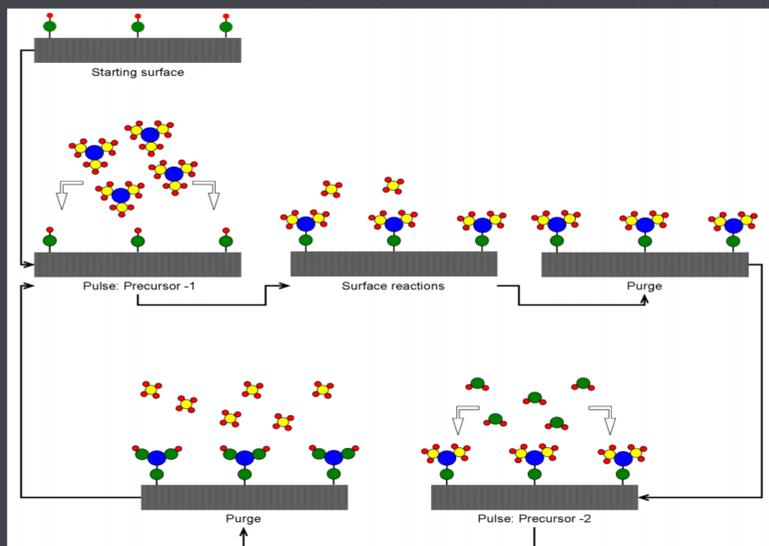
Sample thickness (nm)	θ_1	θ_2
0	33.2	39.7
20	93.8	71.6
30	32.6	43.8
40	52.5	54.7
50	45.5	52
100	81.33	79.5
Gold	59.3	63.3

Contact Angles for droplets on Glass Substrates

Sample thickness (nm)	θ_1	θ_2
0	0	0
20	72.8	67.7
30	79.7	74.8
40	89.8	90.5

Results show that Aluminum Oxide thin films display a more hydrophobic Contact angle in comparison to a clean silicon substrate. The table shows that for the silicon, there was no direct change in hydrophobicity other than the fact that the thin films caused the Aluminum Oxide to become more hydrophobic

ALD Growth Process



Conclusion and Future Work

The Aluminum Oxide thin films caused the silicon to become more hydrophobic. On the silicon substrates, the thin films increasing didn't effect the contact angle as much as it did on the glass. On the glass, as the aluminum Oxide thin films made the Contact angle closer to 90° showing that glass with Aluminum Oxide gets more hydrophobic

For future work we intend to dope the aluminum oxide with zinc and investigate the effect of zinc on:

- Growth rate
- Crystallinity of the films
- Hydrophobic properties

References

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