BACKGROUND

- Atomic Layer Deposition (ALD) - a subclass of chemical vapor deposition (CVD), is widely used to deposit metal oxide films for microelectronics fabrication.
- The ALD process can precisely deposit films at a rate of one monolayer per cycle.
- Commercial ALD systems are expensive (~$150,000), but work done at Central Michigan University outlines a system built for less than $10,000.

OBJECTIVES

- Design, build, and characterize a versatile bench-top ALD system for less than $10,000.
- Create a standard operating procedure to safely handle and install the pyrophoric reactant, trimethylaluminum (TMA), and an operating procedure for the ALD system.
- Achieve deposition of Al₂O₃ and evaluate the feasibility of implementing an ALD lab into the CHE 544/444 lab.
- Expand deposition to other thin film materials for Dr. Feng’s research.

Build an economical ALD system with the capability of performing graduate research and possibly implemented into an undergraduate instructional lab.

COST-EFFECTIVE ATOMIC LAYER DEPOSITION SYSTEM

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RESULTS

- Successful deposition of Al₂O₃ on silicon, see figure 3 for XPS spectrum of material deposited.
- Temperature fluctuation of +/- 10 °C during deposition while holding pressure of 2 torr.

FUTURE WORK

- Expand the system capabilities to additional thin film materials.
- Modify system to reach a lower absolute pressure.

OUR SYSTEM

The gaseous reactants flow from left to right through the ALD chamber. The reaction takes place at the substrate surface as the reactants flow horizontally.

The pneumatic ALD valves are controlled by solenoid pilot valves (SMC, NVZ5120-5LVV-CN3244) for precise substrate temperature control during deposition experiments.

KEY COMPONENTS

- Arduino Microcontroller – used to control the solenoid pilot valves at the microsecond scale to alternate which chemical is sent to the chamber.
- Quartz Crystal Microbalance (QCM) - the QCM (Colesnatec, Phoenix System PC®) will allow for in situ thickness measurements of the deposited film on a separate quartz sensor.
- Temperature Controller – an Omega PID temperature controller (CN3244) is utilized for precise substrate temperature control.
- Argon Mass Flow Controller (MFC) – Argon flow into the system is controlled using an Omega MFC (FMA5408A), allowing for system pressure control during deposition experiments.

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