AUTOMATION OF LAYER BY LAYER THIN FILM METAL ORGANIC FRAMEWORKS

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Metal Organic Frameworks

Metal-organic frameworks (MOFs) are crystalline hybrid organic-inorganic solids constructed with metal ions. Crystals are typically synthesized using solvothermal methods, which require long growth times, use of harsh solutions, high temperatures and pressures, and lead to poor adhesive properties when deposited on substrate. Layer-by-layer growth improves adhesion due to direct chemical bonding to substrate, allows for versatility in thin film properties, and provides precise control of layer thickness. Uses for MOFs include gas storage, separation, sensing, and catalysis.

MOF Properties

- Large internal surface area
- High porosity
- High thermal stability
- Ability to tailor framework properties

Opportunity: Improve an existing automation system to perform layer-by-layer thin film deposition that will produce repeatable and uniform film growth for more efficient testing of film properties.

Project Objectives

- Improve LabVIEW code and automation control
- Facilitate deposition of different substrate geometries
- Achieve thin film uniformity
- Improve deposition reproducibility
- Determine precursor dip times for film uniformity

Results

Figure 4 Average surface roughness results from AFM analysis using 12 cycles with 30 min. Cu²⁺, 60 min. BTC dip times to grow Cu-BTC thin films. In both horizontal and vertical drying configurations, the 10 min. wash time showed the best uniformity results with a lower surface roughness.

Future Work

- Implement rinse station pump to provide fresh ethanol for every rinse sequence
- Investigate cycle count relationship to film thickness and uniformity
- Investigate the affect of different substrate geometries on system performance
- Improve LabVIEW code to allow nitrogen drying flowrate input

Acknowledgments

Thank You:

- Dr. Chih-Hung Chang for support and funding.
- Yujing Zhang for assistance in lab and dedicated time to guide the project.
- Joe Bergevin for AFM training and assistance.
- Dr. Phil Harding for project feedback and organizing CBEE 416 design course.
- Oregon State University, HP, and ATAMI for facilities use.

Figure 1 Chemical bonding of copper to an oxide layer provides strong adhesive properties and allows for BTC to attach and form crystalline MOF structures. The Cu-BTC crystals shown above were grown using 12 cycles with 30 min. Cu²⁺, 60 min. BTC, and 10 min. ethanol wash dip times.

Figure 2 Atomic force microscope analysis scan locations on the Cu-BTC thin film to determine uniformity.

Figure 3 200µm x 200µm atomic force microscope scans at the center of wafers with Cu-BTC grown using the automation system. All three wafers were exposed to 12 cycles with 30 min. Cu²⁺ and 60 min. BTC dip times. A) A non-uniform film developed when exposed to 1 min. EtOH wash times. B) A uniform film developed using 10 min. EtOH wash times and horizontal drying. C) A uniform film developed using 10 min. EtOH wash times and vertical drying.