



# SCIART: Protection of Silver Objects from Corrosion using Atomic Layer Deposited Barrier Coatings

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## Motivation

The corrosion of silver artifacts is a monumental problem for art collections. A novel multilayer, multifunctional barrier coating for silver is proposed using the atomic layer deposition (ALD) of metal oxides to reduce the rate of silver corrosion, while complying with the rigorous standards of art conservation practice. This museum and university partnership will result in an effective, low-cost strategy to reduce silver artifact corrosion, while preserving artifact appearance and composition.

## Current Techniques for Silver Conservation



Walking Lion of Antoine-Louis Barve before and after polishing.

### Polymeric Nitrocellulose:

- Manually remove aged nitrocellulose
- Polish, etch, recondition surface
- Spray or brush on nitrocellulose
- 3 to 40+ hours to treat an object
- Lasts ~10 years

### Limitations:

- Application and removal is labor and time intensive
- Challenging to achieve uniform coating on 3-D objects



Hand polishing and nitrocellulose application of objects is labor and time intensive.

### Polishing and Encasing:

- Manually remove Ag<sub>2</sub>S tarnish layer
- Control environment around objects
- Encase objects with sulfur getting materials

### Limitations:

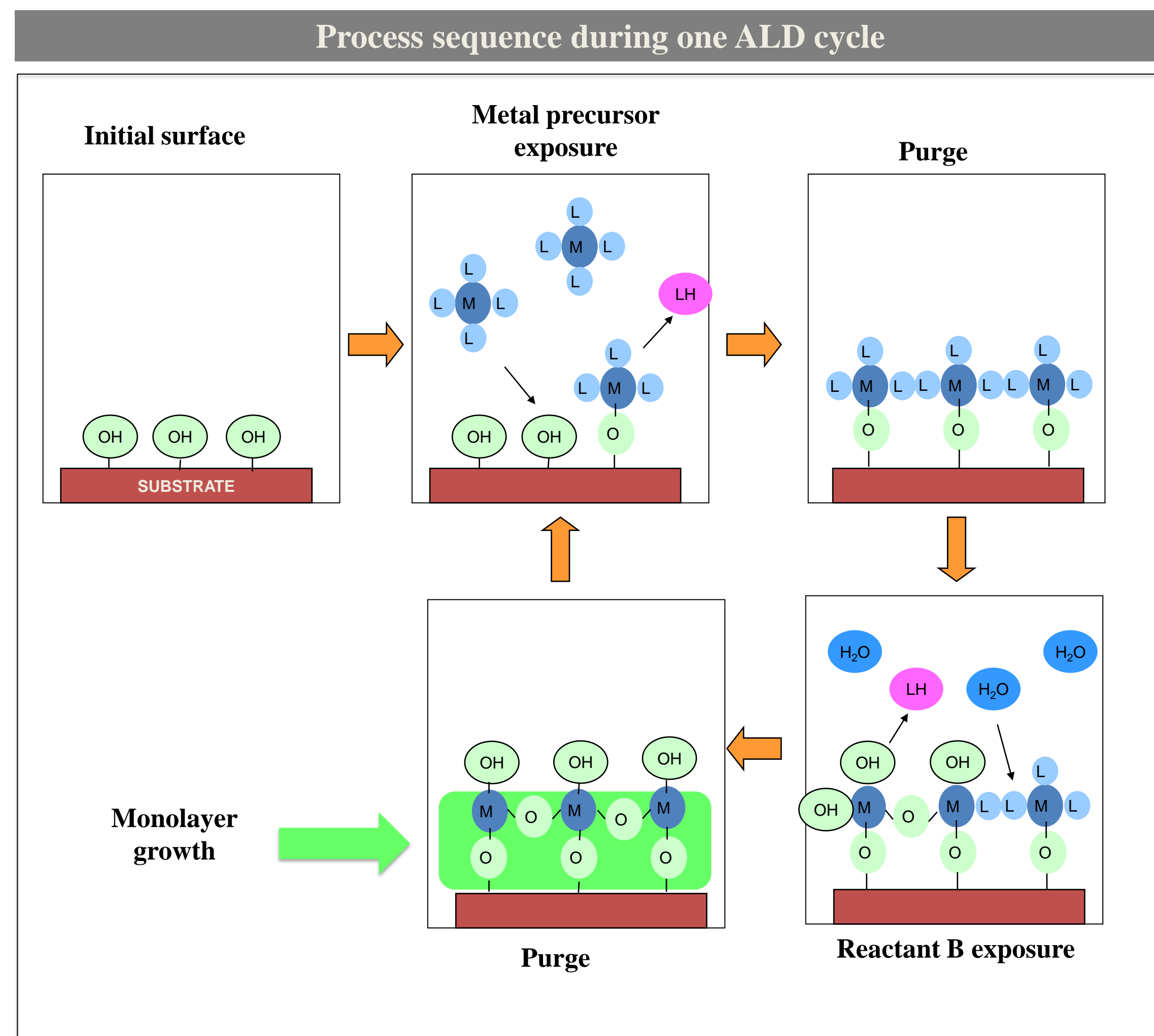
- Labor and time intensive
- Removes material
- Lose surface details over time



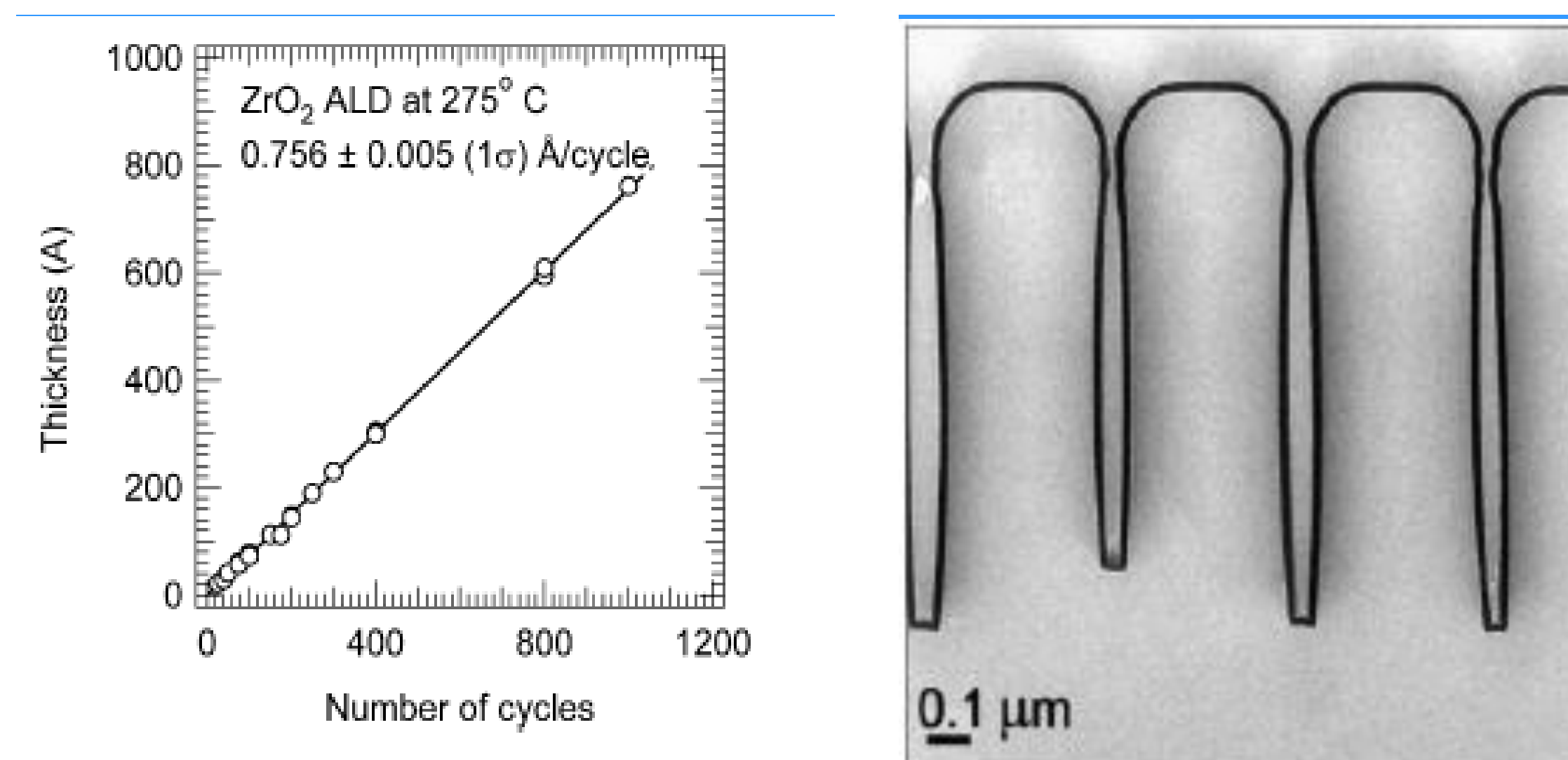
Display cases for silver objects at the Metropolitan Museum of Art with activated carbon filters to reduce atmospheric sulfur concentrations.

## Methods

### Atomic Layer Deposition (ALD):



### Thickness and Conformality



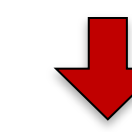
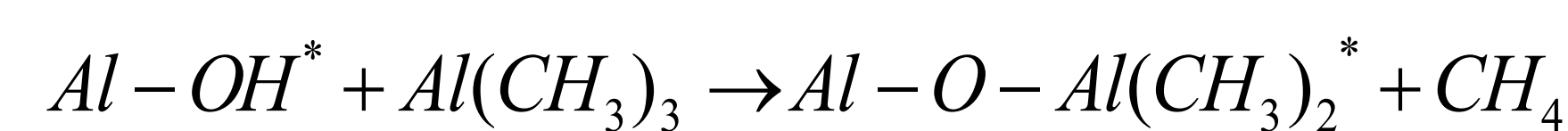
Examples of thickness control, conformality and nanolaminate structures achieved by ALD.

### Surface reaction during one ALD cycle

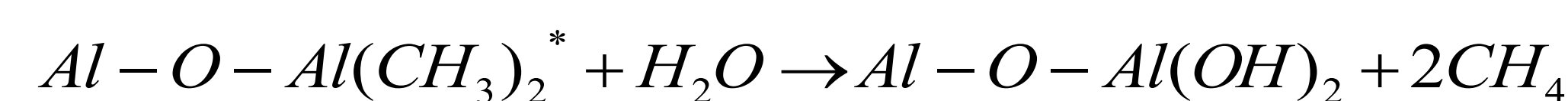
Reactive CVD precursors alternately and separately exposed to surface



Self-limiting adsorption/reaction

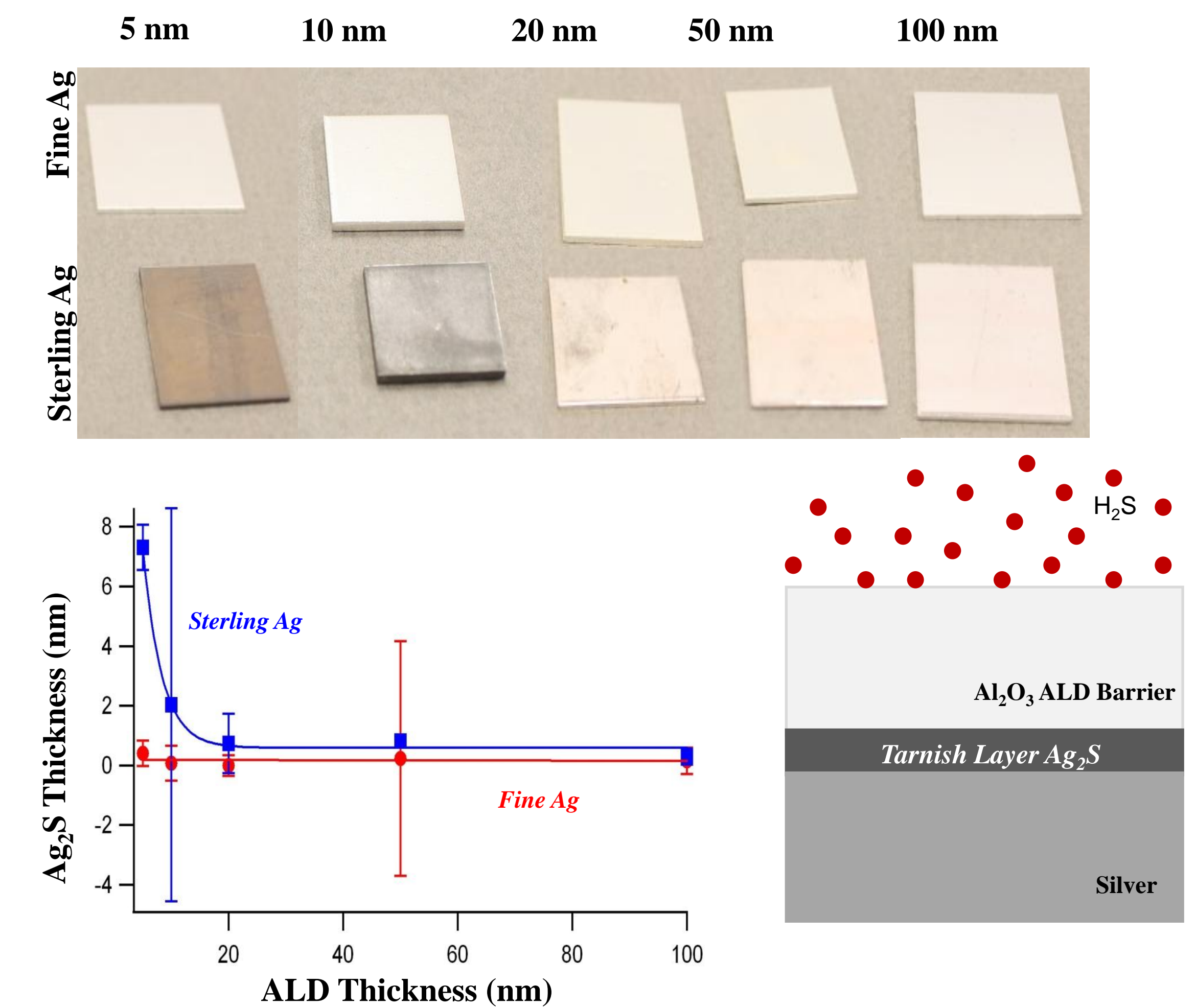


Monolayer control, superb conformality and uniformity



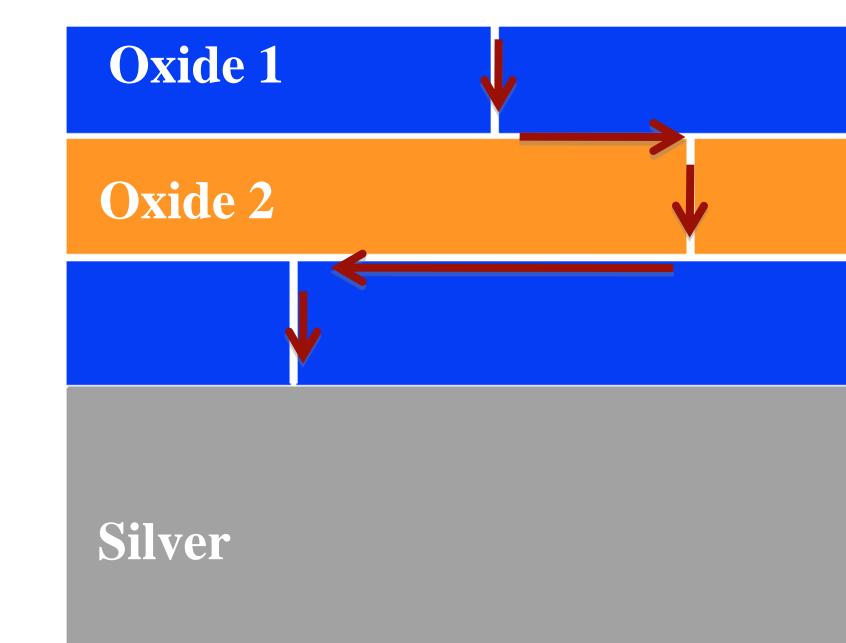
## Preliminary Results

### Accelerated Tarnishing of Varying ALD Thickness:



Increasing the thickness of the ALD thin film decreases the thickness of the Ag<sub>2</sub>S layer formed at the interface, reducing the tarnish rate for sterling (92.5%Ag-7.5%Cu) silver; a rough fit to an exponential gives a characteristic thickness of ~3nm. The tarnishing rate for fine silver is orders of magnitude lower, indicating reaction limited kinetics.

## Future Work



• Determine lifetimes and color of ALD thin films compared to nitrocellulose

• Determine effect of polishing techniques on ALD film performance

• Characterize reversibility of ALD coatings – Surface composition, topography, and color of surfaces after chemical and mechanical removal of films

• Effect of topography, patterns on functionality and reversibility of ALD films