Atomic Layer Deposition (ALD) Conformality in Nanopores

Rubloff Research Group Accomplishments

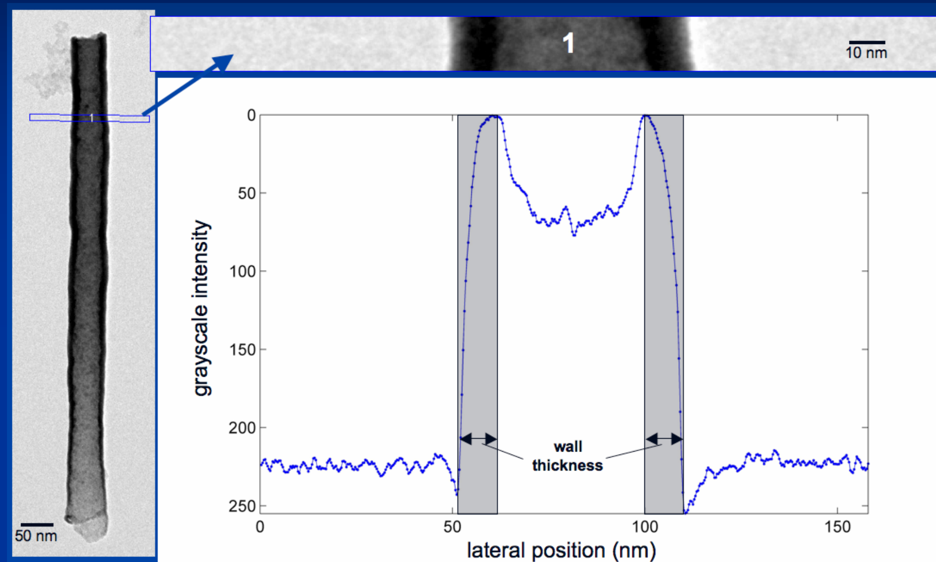
ALD Conformality in Nanopores

Accomplishment

- Developed methodology to analyze conformality of ALD films in ultrahigh aspect ratio nanopores.
- Demonstrated quantitative capability using ALD deposition into anodic aluminum oxide nanopore templates, removal of template, and subsequent TEM analysis.

Significance

- Atomic layer deposition (ALD) is widely sought for its atomic-scale thickness control and unprecedented uniformity and conformality.
- Quantifying and understanding ALD conformality in the most demanding aspect ratio nanostructures is challenging yet essential to realizing nanostructured devices.
- The new methodology provides a stringent test and rapid quantitative analysis of ALD conformality in the most demanding nanostructures, revealing ALD process capability and limitations for its nanodevice applications.



Researchers involved

Israel Perez, Parag Banerjee, Erin Robertson, Laurent Henn-Lecordier, Gary W. Rubloff

Support

Laboratory for Physical Sciences, MKS Instruments, NSF MRSEC (seed)

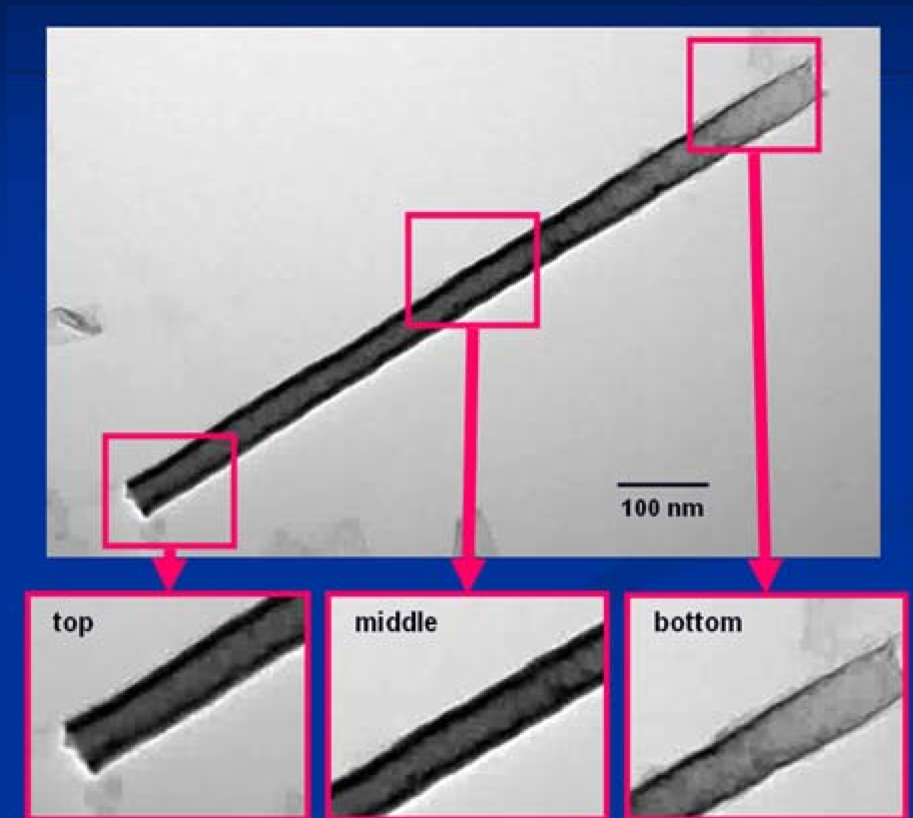
ALD Conformality in Nanopores

Intellectual merit

While atomic layer deposition (ALD) enables unprecedented control of atomic layers of material over 3-D surfaces, knowledge of its uniformity limits in ultrahigh aspect ratio nanostructures is limited.

We have developed a methodology to quantitatively assess ALD conformality in nanostructures, based on ALD into anodic aluminum oxide (AAO) nanopore templates, their chemical release from the AAO, TEM imaging, and algorithms to extract wall thickness vs. depth from the remaining ALD nanotubes.

ALD thickness profiles provide a direct evaluation of conformality and comparison to existing models for ALD process conformality.



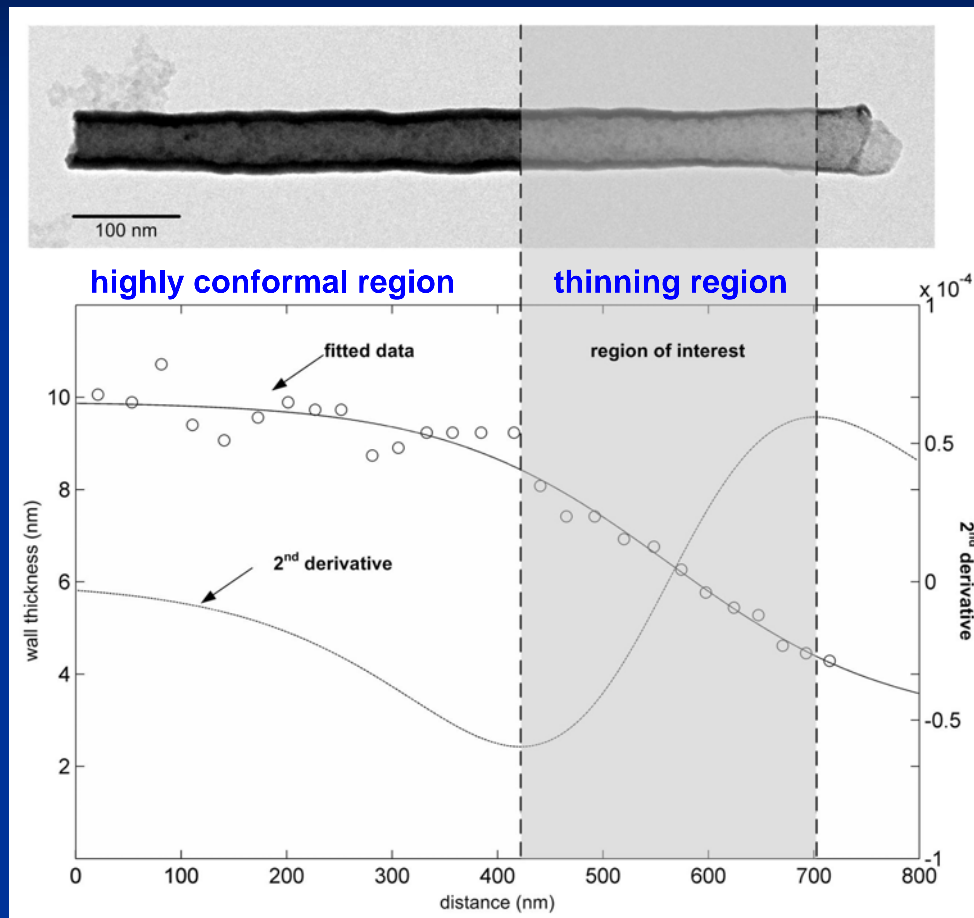
ALD Conformality in Nanopores

Broader Impacts

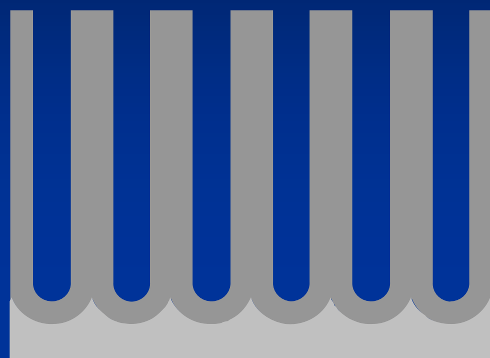
Because of its atomic-scale thickness control and unprecedented uniformity and conformality, ALD presents an attractive route to fabrication of nanodevice structures in broad applications, including energy, displays, and targeted drug delivery nanoparticles.

Achieving viable nanodevice applications requires not only understanding of conformality mechanisms, but effective methods for conformality metrology in these demanding geometries, methods which are realized and demonstrated here.

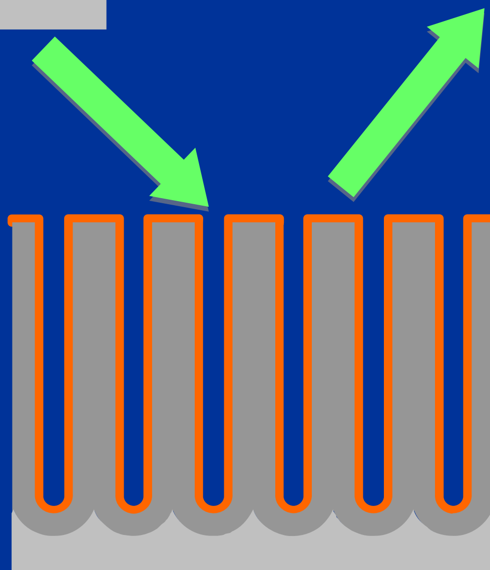
The ALD conformality determination method described here provides rapid quantitative results that are much easier, faster, and more precise than are conventional approaches based on cross-sectional TEM or SEM.



Imaging ALD Nanoprocess Characteristics using AAO Nanopore Templates



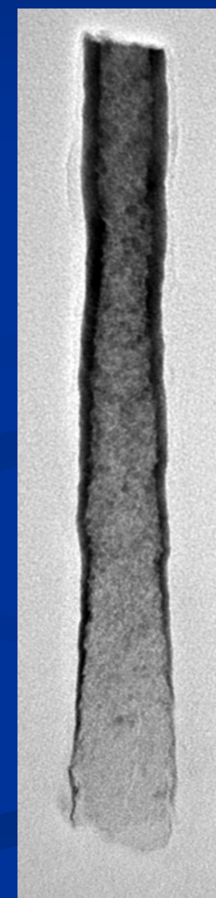
1. Anodic aluminum oxide (AAO) nanopore template



2. Atomic layer deposition (ALD) into nanopores

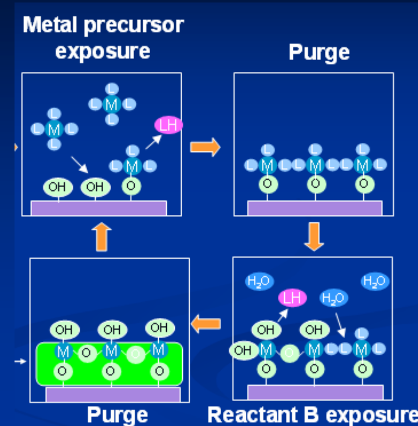
3. Etch away AAO to release ALD nanotubes

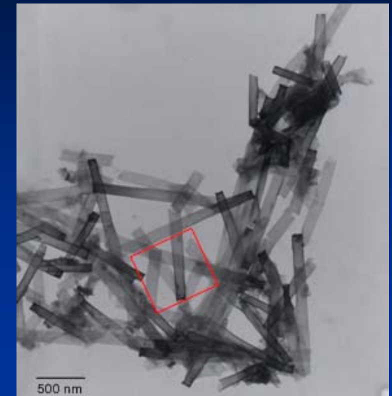
4. Characterize ALD nanotubes by TEM metrology

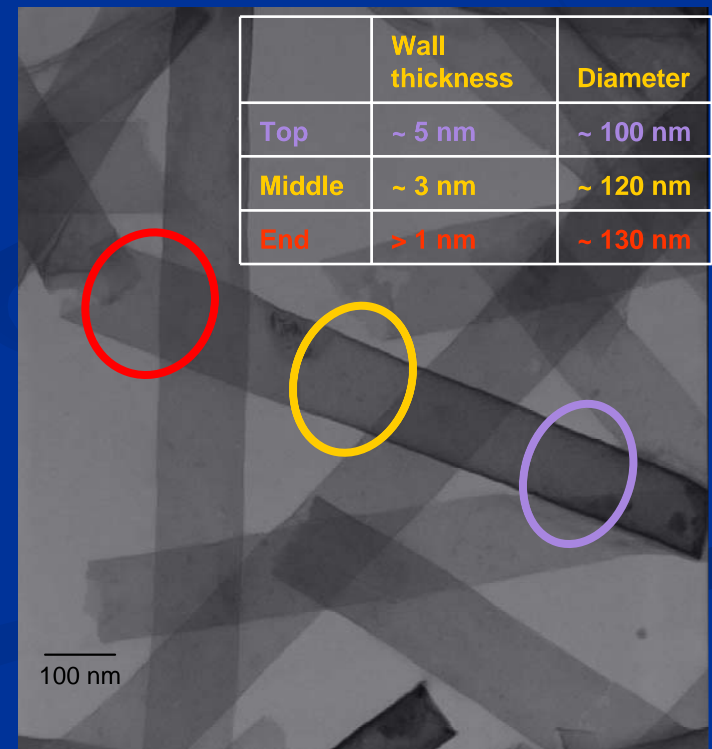


Atomic Layer Deposition (ALD)

- ***Self-limiting deposition* of ultrathin films in AAO nanopores**
- Atomic layer deposition (ALD): alternating exposures of reactant gases to cause self-limiting adsorption and reaction
- Deposition controlled at atomic scale even in superhigh aspect ratios (e.g., nanoscale pores)
- The ultimate in thin film deposition control to manufacture nanostructures from AAO templates







	Wall thickness	Diameter
Top	~ 5 nm	~ 100 nm
Middle	~ 3 nm	~ 120 nm
End	> 1 nm	~ 130 nm

TEM-based Nanotube Metrology