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SENIC Southeastern Nanotechnology Infrastructure Corridor

Effectiveness of Grown Poly(methyl methacrylate)/PMMA Brush as a Masking Agent

Jonathan L. Chang

Mentor: Amar T. Mohabir

Principal Investigator: Prof. Michael A. Filler

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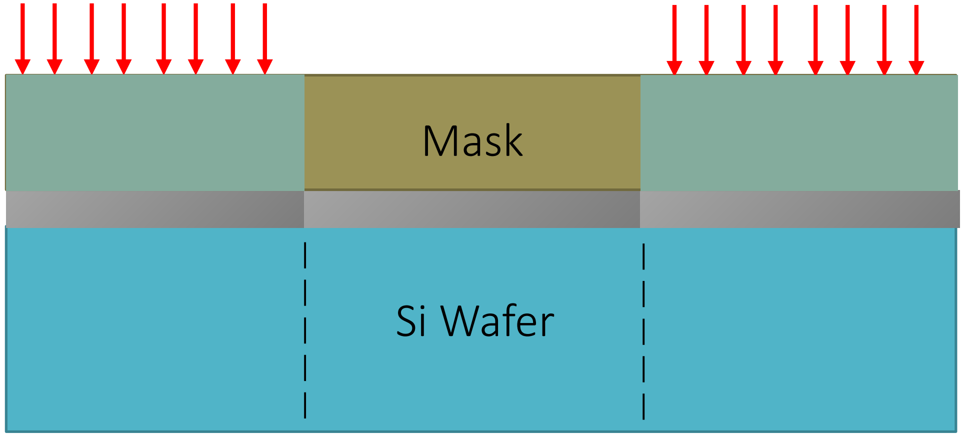
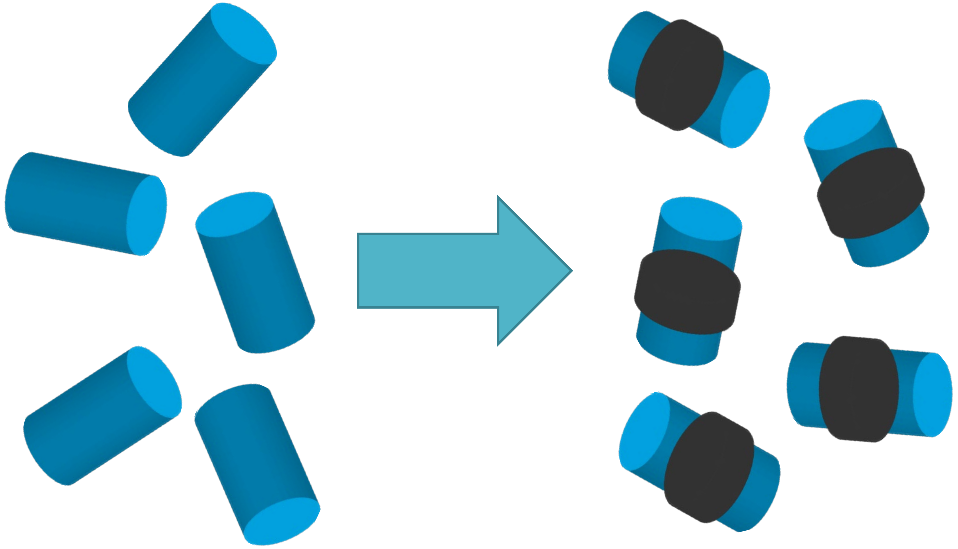
2D vs 3D Fabrication



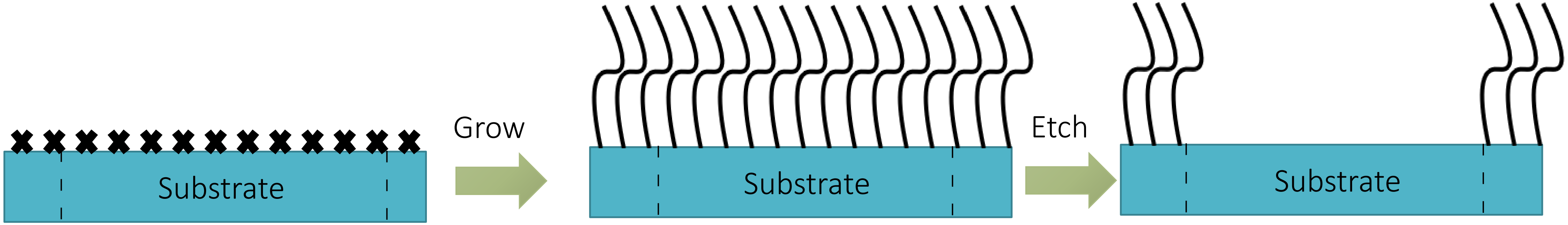
Etching
Top-Down

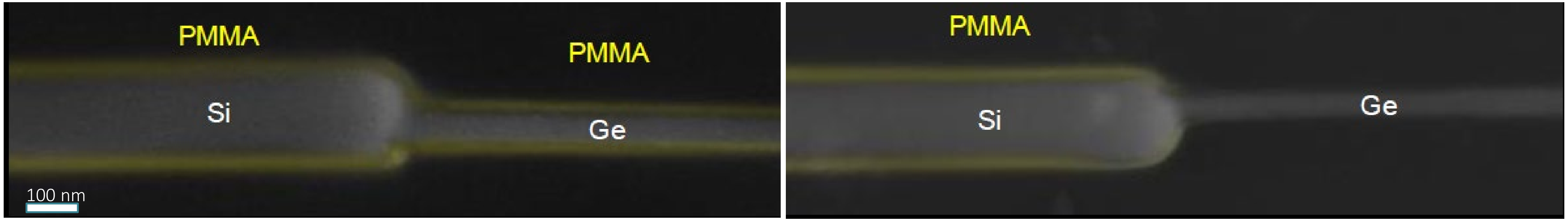
Difficult to make nanostructures in 3D



Selective CoAxial Lithography via Etching of Surfaces (SCALES) Process[1]

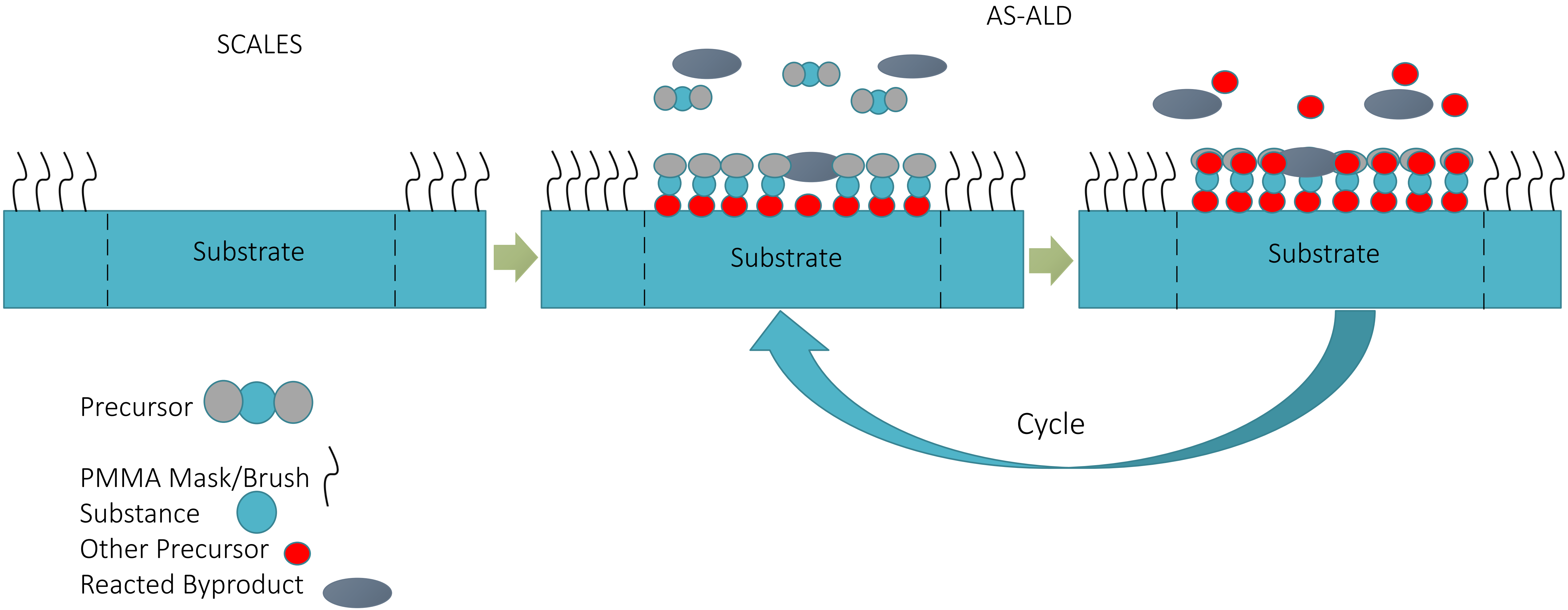
- Lead to Fully Bottom-Up Fabrication Process
  - Polymerization from surface of nanostructure via atom transfer radical polymerization





Mohabir, et. al. Submitted 2019

Area-Selective Atomic Layer Deposition (AS-ALD)



Grown PMMA Brush as an Effective Mask

Goal: To investigate and optimize the masking ability of grown PMMA brush

Focus is on the AS-ALD step after SCALES

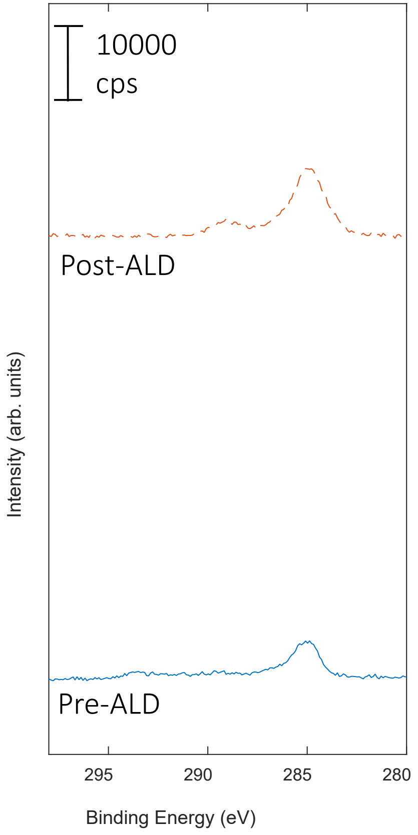
- See if grown PMMA brush prevents ALD on covered areas
- Process specifications of ALD which affect masking abilities
- Want to be able to selectively remove mask and not deposited material

Experimental Overview

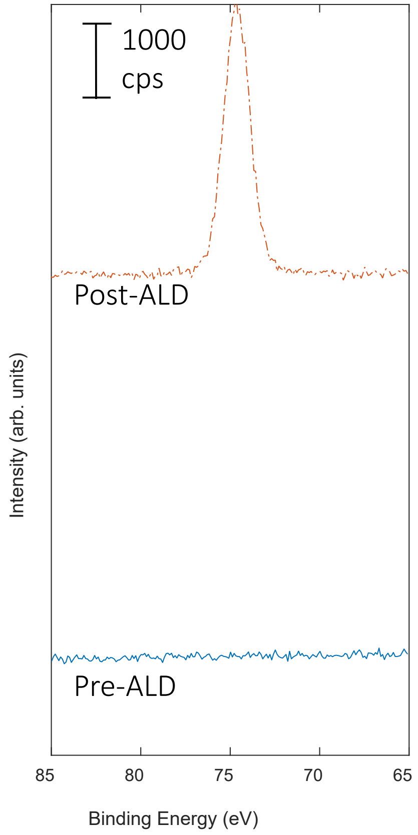
- Performed 10 cycles ALD on Si wafers and Si w/PMMA (~30nm grown)

Bare Si

C1s

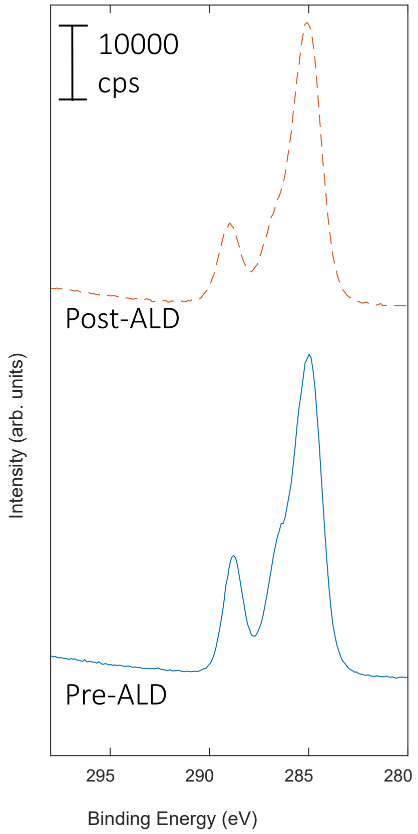


Al2p

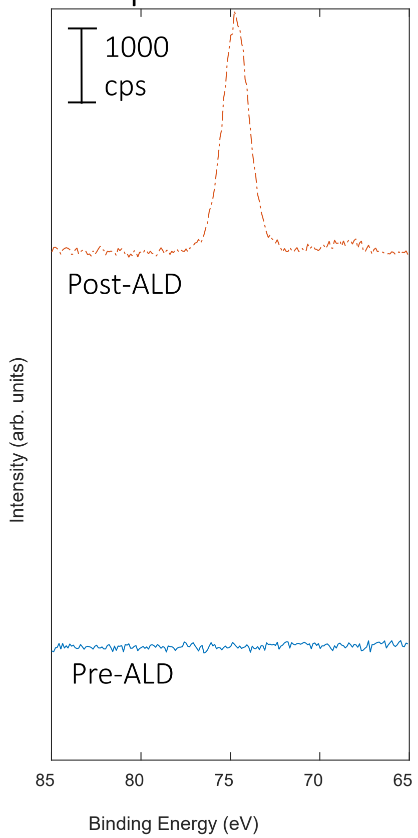


PMMA

C1s

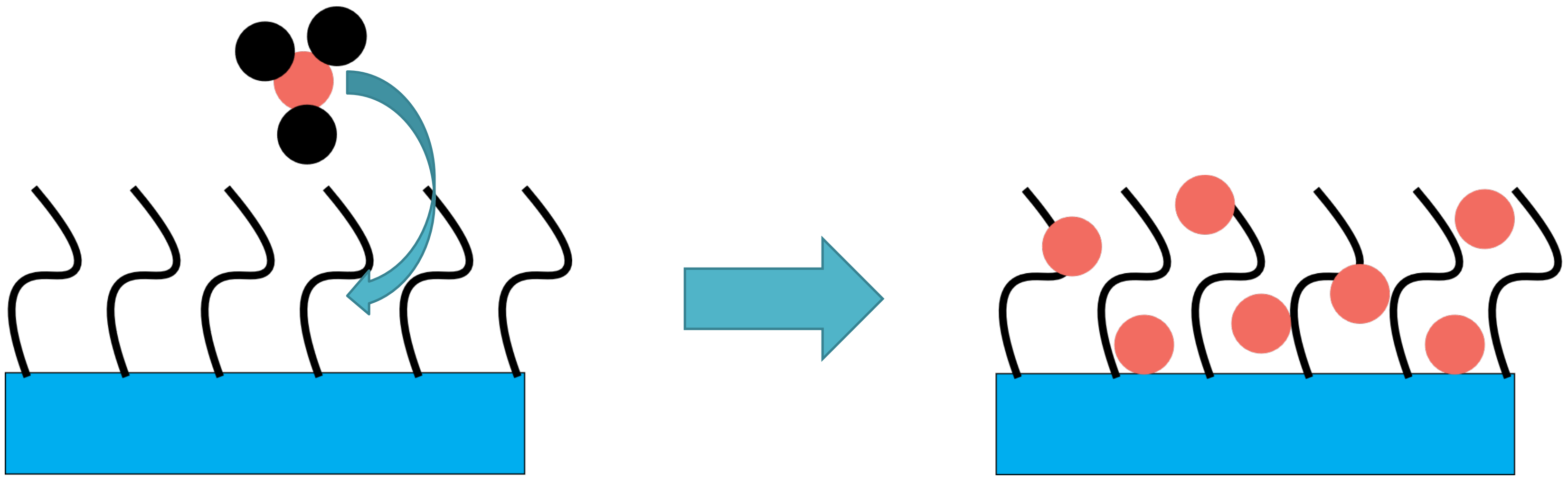


Al2p

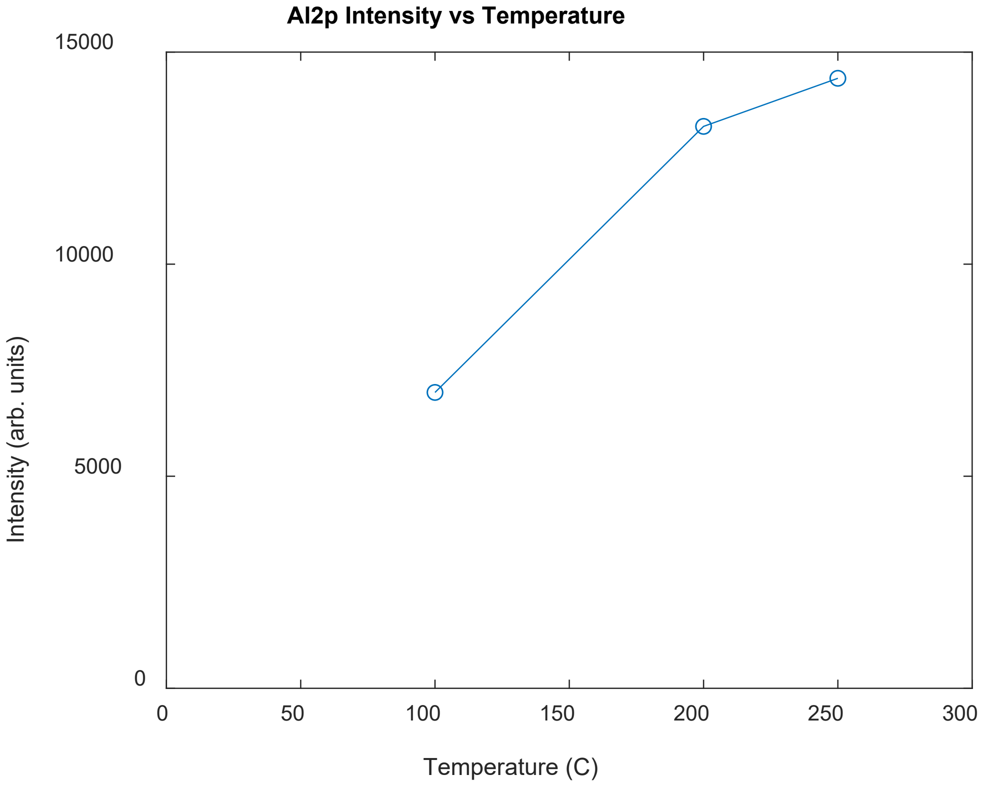


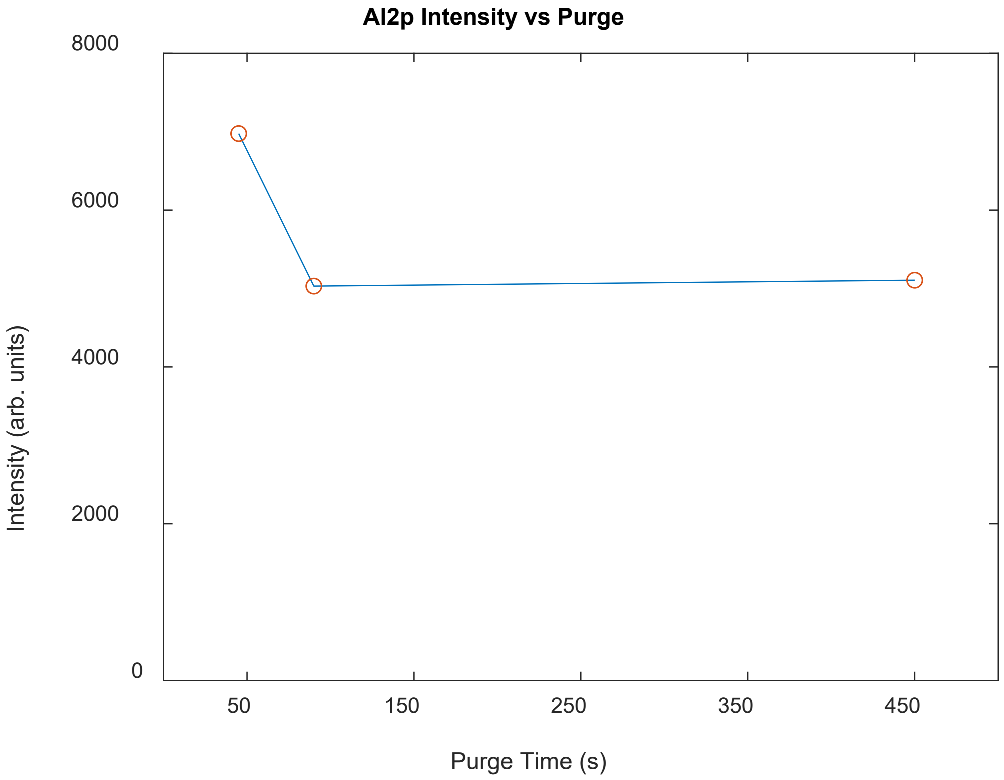
Precursor Diffusion/Reaction in PMMA

- Precursors such as trimethylaluminum (TMA) diffuse in PMMA[2]



Effects of ALD Process Variables

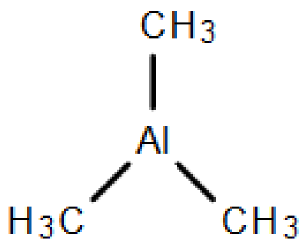




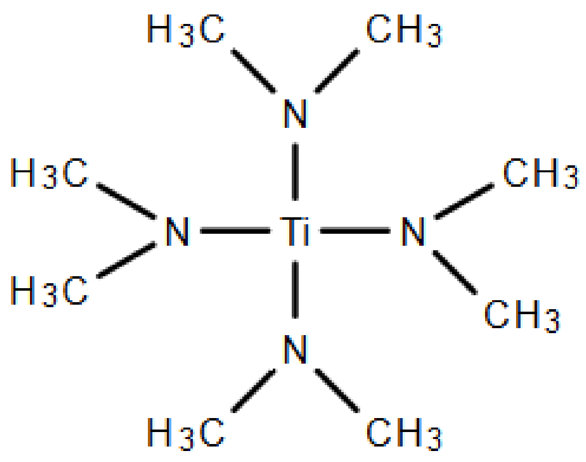
- Temperature and Purge Times have an affect on alumina in PMMA
- There’s still alumina in PMMA (1000 arb. units is significant)

Changing Precursors/Material

- Other ALD processes are more selective on spin-coated PMMA^2
  - Changed deposited material
    - *HfO_2, Pt, TiO_2*



Trimethylaluminum



Tetrakis(dimethylamido) Titanium

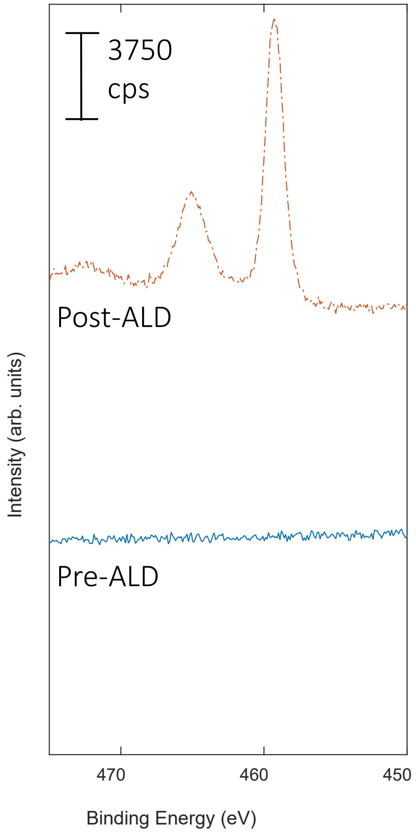
TiO_2 ALD on PMMA

TiO_2 Deposition on bare Si

Grown PMMA has no significant Ti

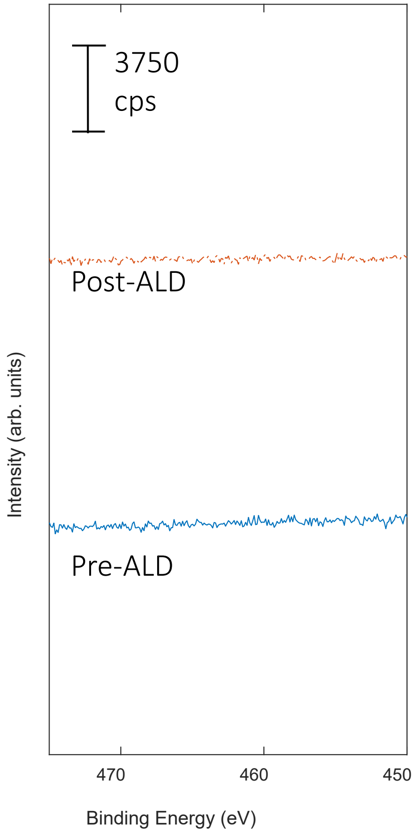
Bare Si

Ti2p



PMMA

Ti2p



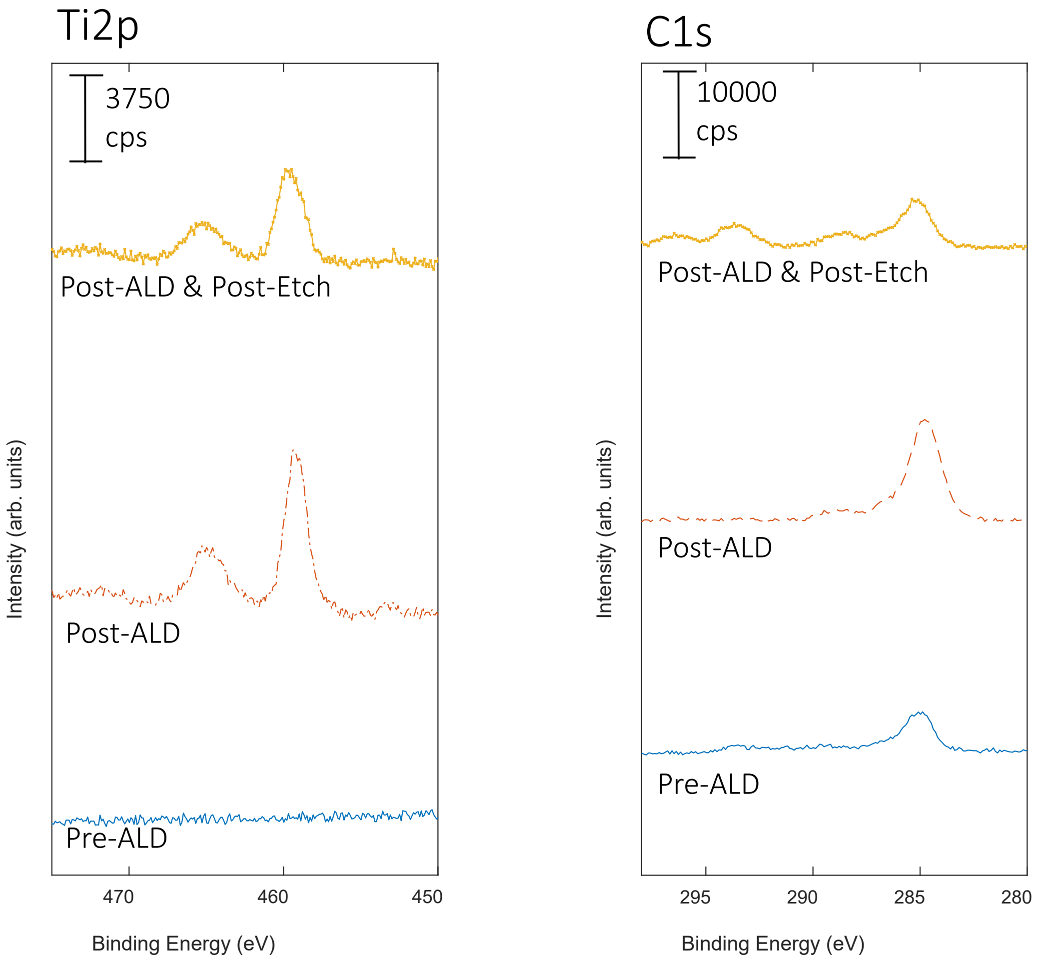
Selective Etching of Grown PMMA Brush

After AS-ALD, want to remove PMMA mask while keeping deposited material

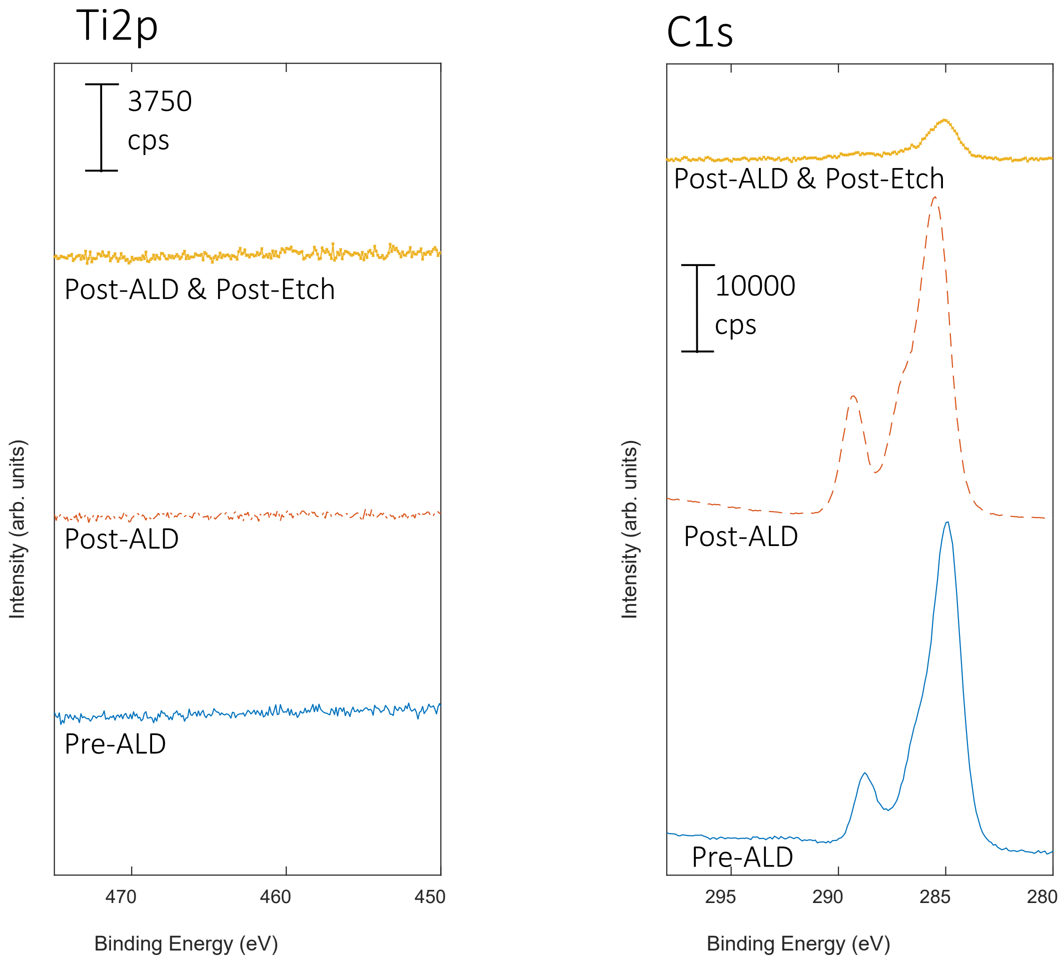
- Wet Chemical Etching
    - Piranha Solution
    - Standard Clean-1 Solution
- Dry Etching
    - O_2 Plasma

O_2 Plasma Etch

Bare Si



PMMA



O_2 Plasma selectively etches PMMA, but not TiO_2

Conclusions

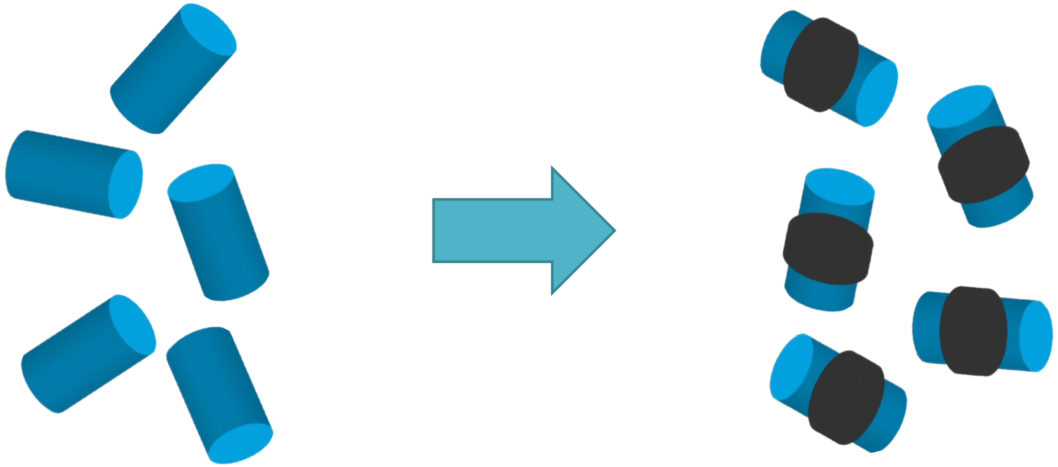
Main factors in grown PMMA brush effectiveness as a mask

1. Precursor Size/Chemistry (**Major**)
2. Temperature (**Minor**)
3. Purge times (**Minor**)

PMMA can be selectively etched off without significant damage to deposited oxide using O_2 plasma

Future Plans

- Use a bulkier precursor for alumina ALD
- Test on nanowires
  - Repeat what I’ve done on substrates with nanowires
- Implement SCALES & AS-ALD to create functioning 3D nanodevices



Acknowledgments

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- Cornell
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QUESTIONS?

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