Deposition of Alkanethiolate Self-Assembled Monolayers on Germanium

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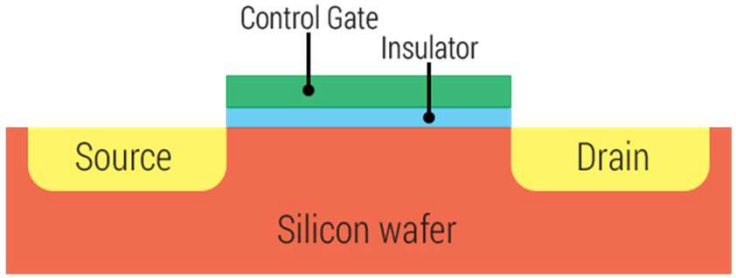
Motivation and Background

- Problem: Ge form unstable oxides that inhibit device performance.
  - Need to find effective surface passivation method for Ge at reasonable time scales
  - Passivation layer = coat of protective material that reduces the amount of chemical reactivity on the surface

Material	Hole Mobility (cm^2 V/s)
Silicon	200
Germanium	450

Del Alamo, Jesús A. "Nanometre-scale electronics with III-V compound semiconductors." *Nature* 479.7373 (2011): 317-323.



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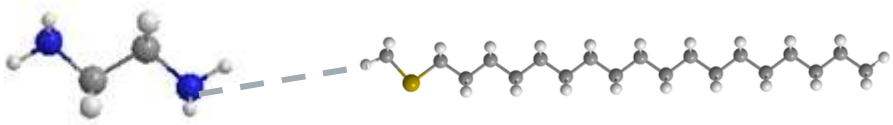
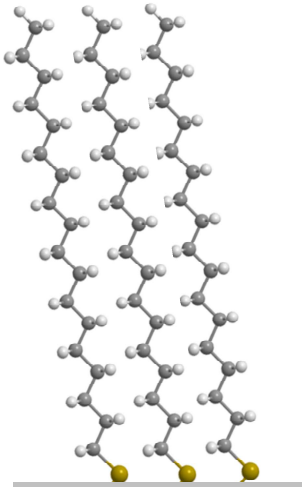
Motivation and Background

- Use octadecanethiol (ODT) as passivation reagent.
  - Long-chain thiol
  - Used successfully in literature, but at long time scales (20 h)
    - Not practical for industry
- **Goal:** reduce passivation time by adding ethylenediamine (EDA)



EDA converts thiol to thiolate.



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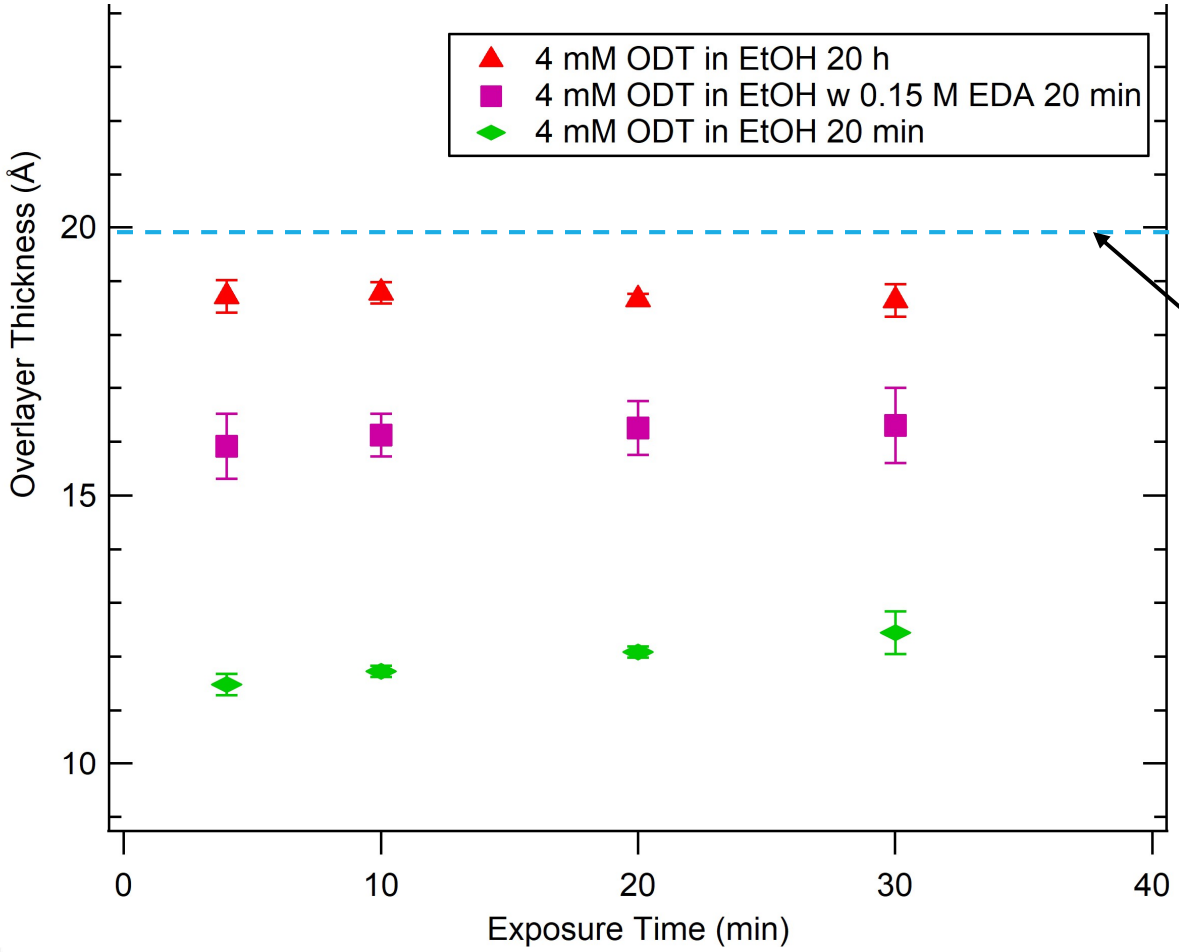
Adding amine increases layer thickness



Ideal overlayer thickness

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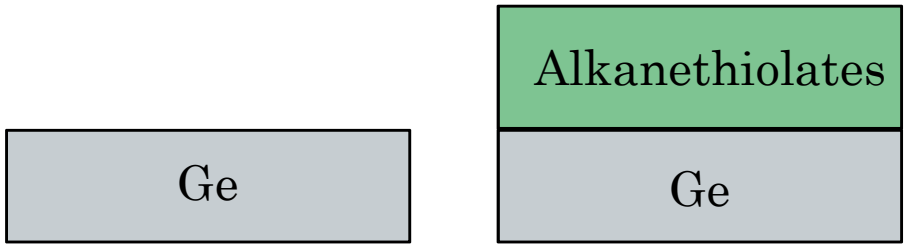
Objective

- **Goal:** Reduce the deposition time of a dense, highly-ordered alkanethiolate passivation.



Control

Alkanethiolate-passivated surface

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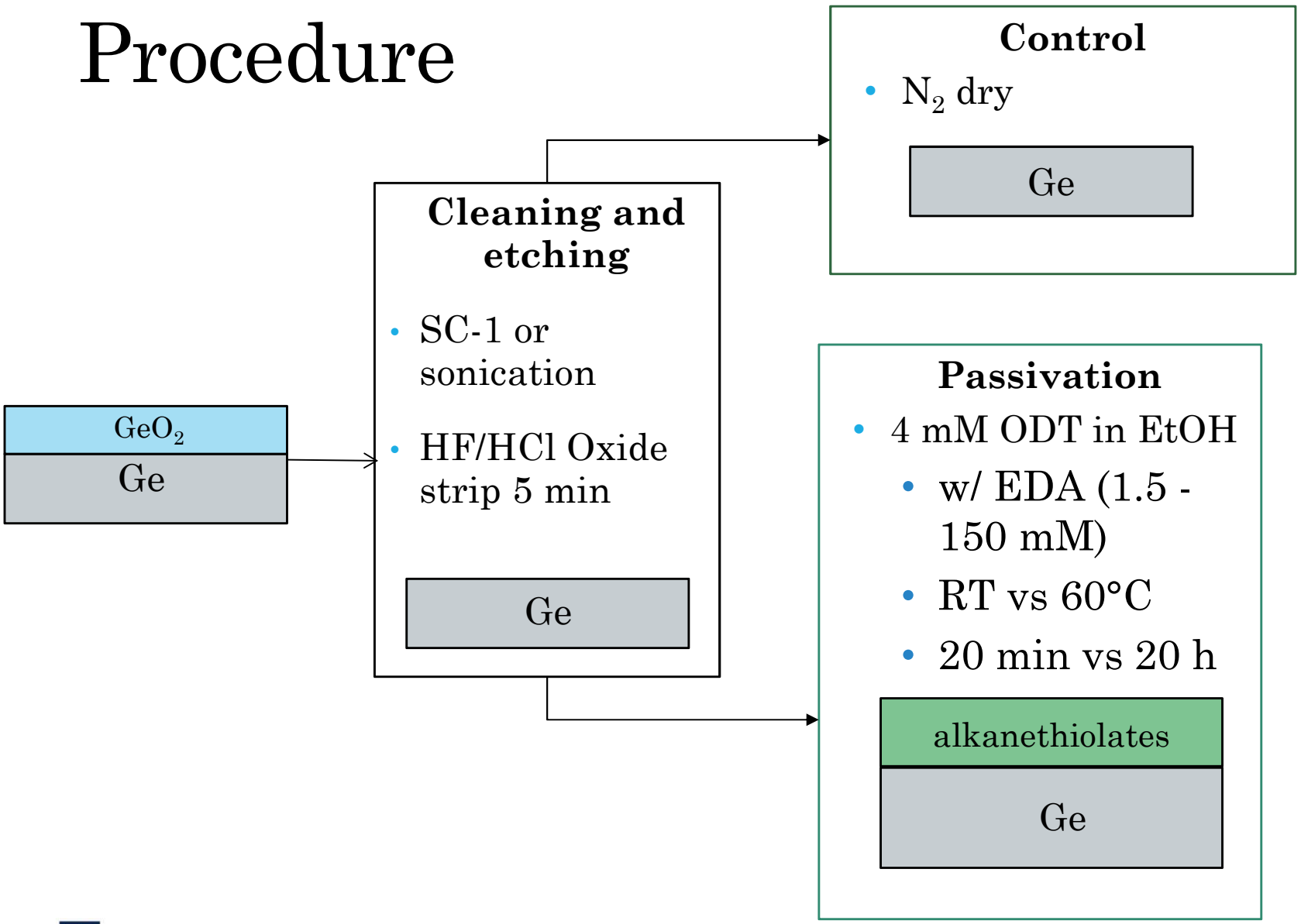
Procedure



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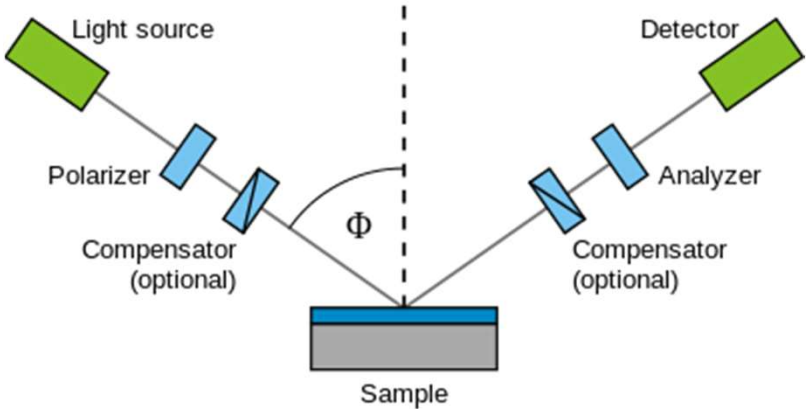
Characterization

Spectroscopic ellipsometry

- Measured overlayer (oxides) thickness

X-ray photoelectron spectroscopy (XPS)

- Determine chemical species on surface.



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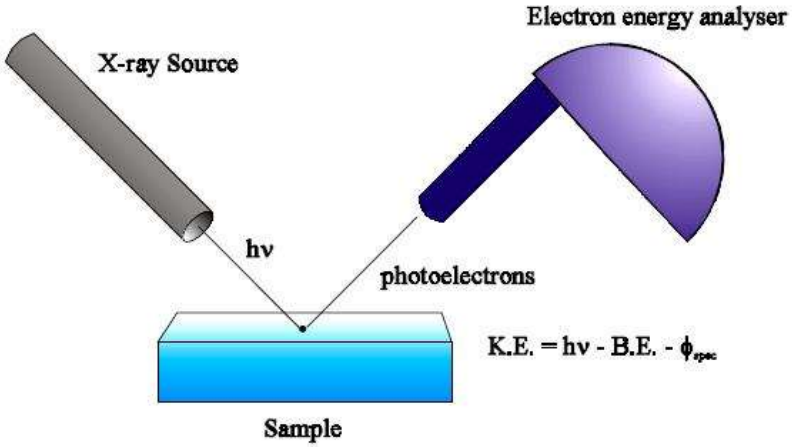

Wikipedia

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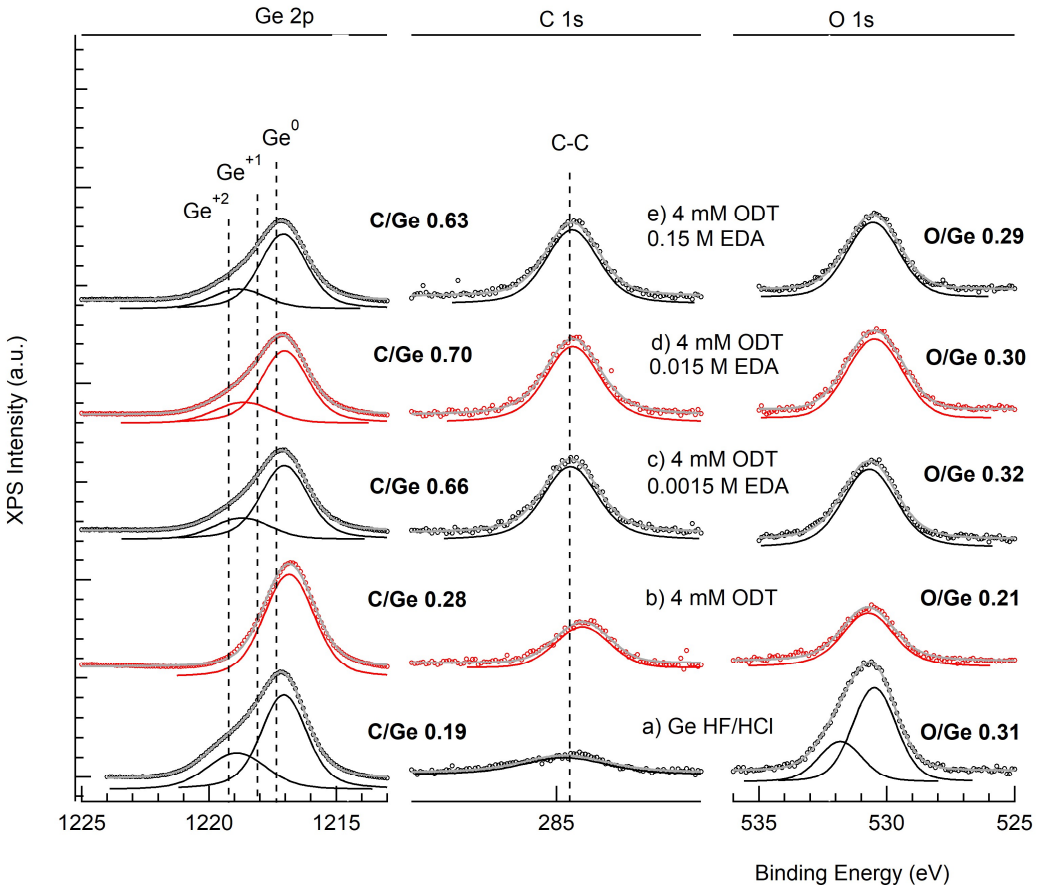
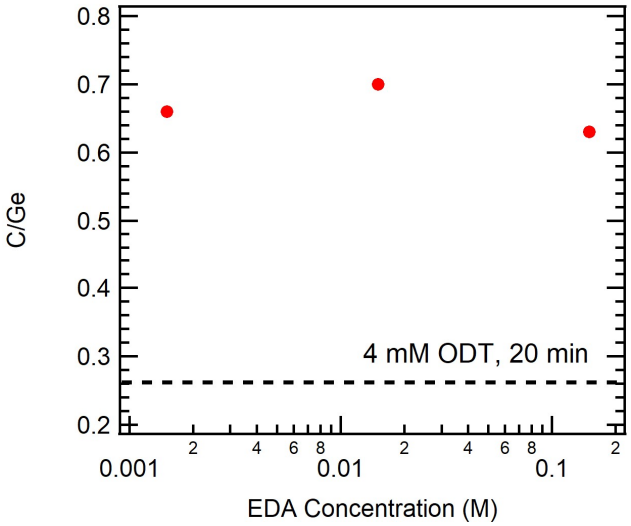
Amine increases carbon coverage





- Amine does not oxidize the surface.
- Concentration of amine does not affect coverage

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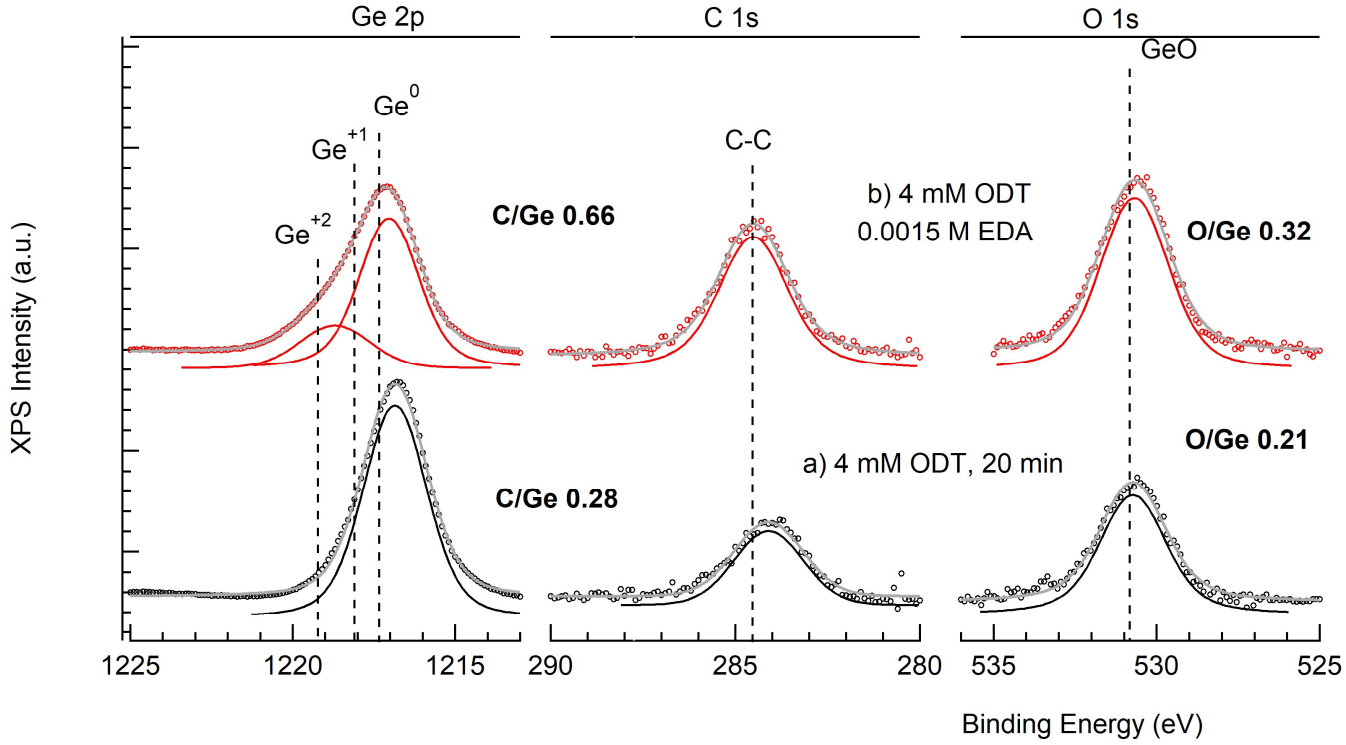
For 20 h immersion, amine decreases C/Ge ratio



- At 20 h, thiol and amine solutions show a decrease in the C/Ge ratio than just thiol alone.

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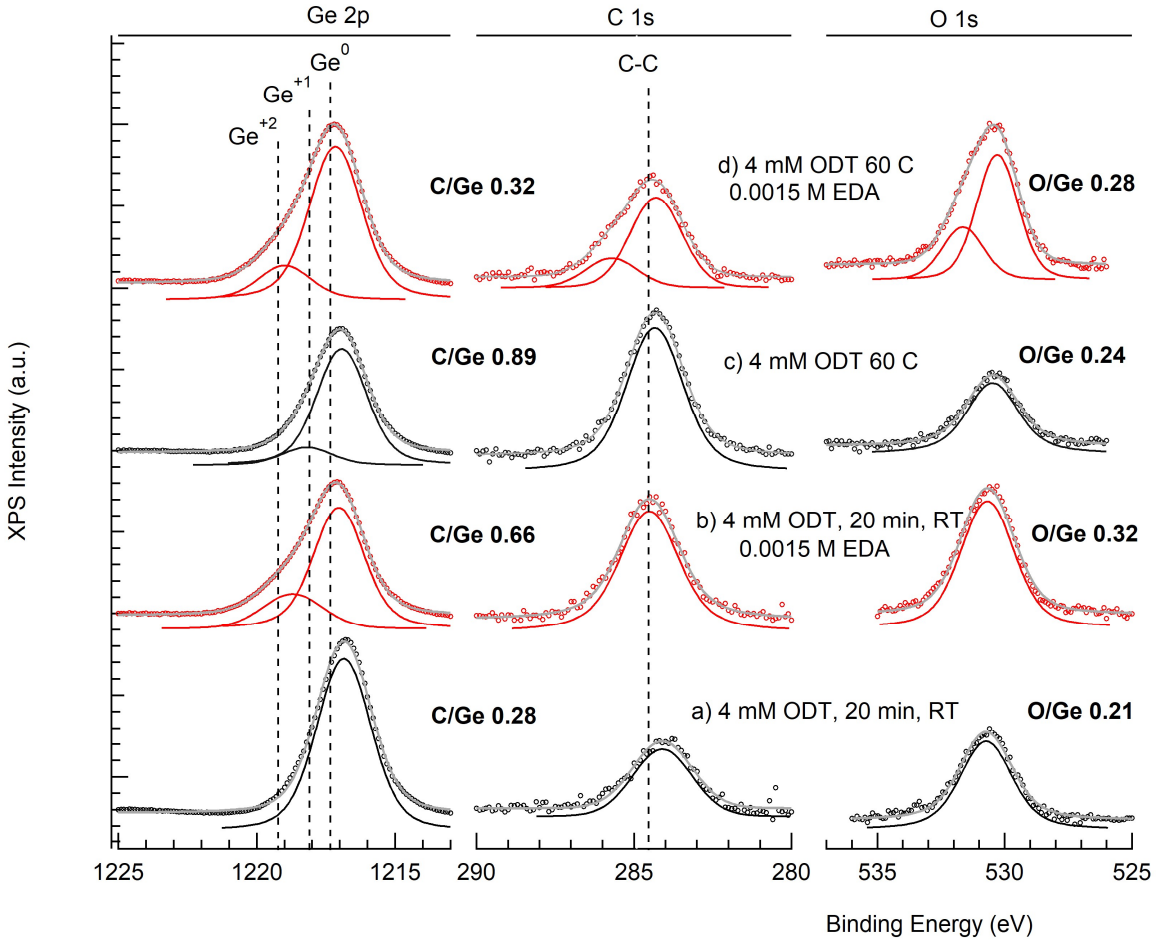
Increasing temperature with amine decreases C/Ge ratio



- Increasing temperature increase C/Ge ratio for thiol alone, but decreases C/Ge ratio for thiol and amine solutions.

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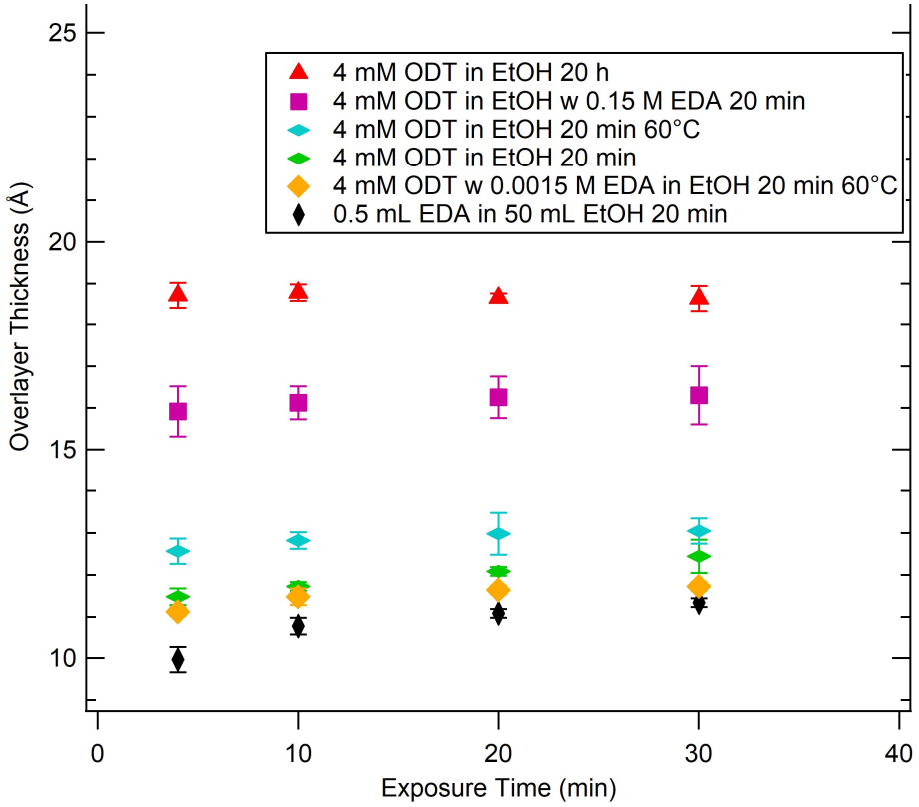
Overlayer thickness corroborates XPS results



- With EDA, increasing T
  → Lower thickness
- At 60°C, adding EDA
  → Lower thickness
- At RT, adding EDA
  → higher thickness
- ODT alone, increasing T
  → higher thickness

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Conclusions

- EDA helps at RT and does not contribute to oxidation.
- 20 h immersion produces a more dense and highly-ordered layer than 20 min immersion
- Increasing temperature for solutions with EDA does not produce a more dense and highly-ordered layer.

Future Work

- Confirm temperature trends.

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Acknowledgements

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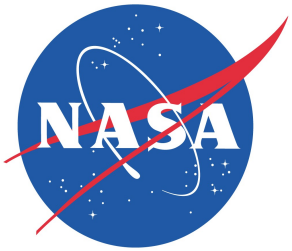
Lam Research



Thank you!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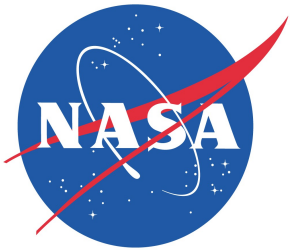
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