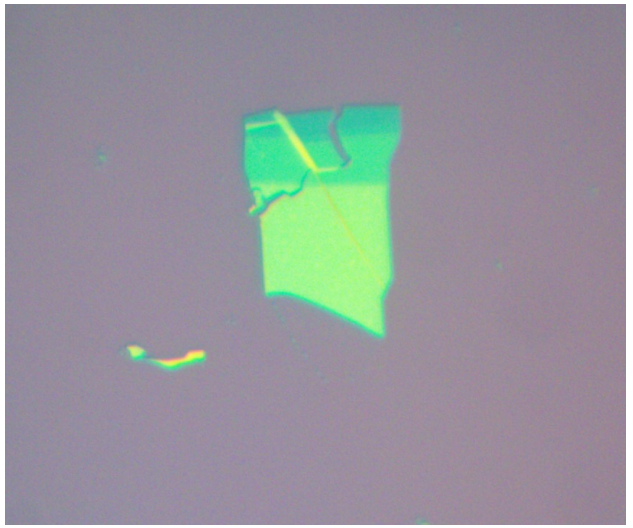
Decreasing the Noise of Graphene Biosensors by Changing Capacitance



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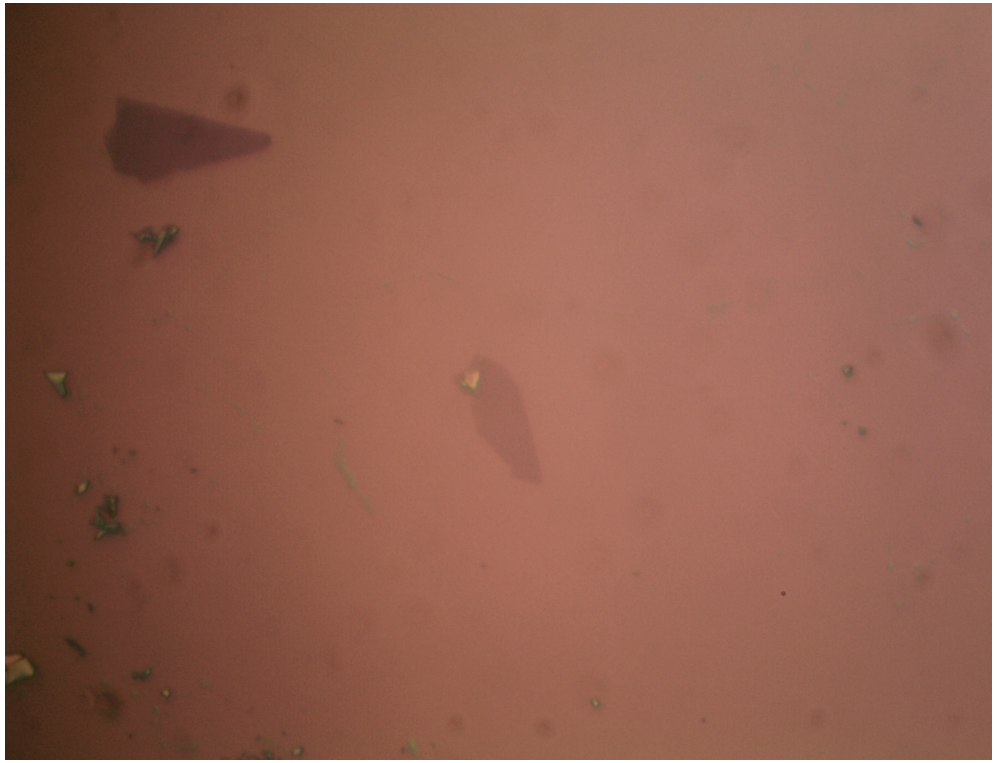
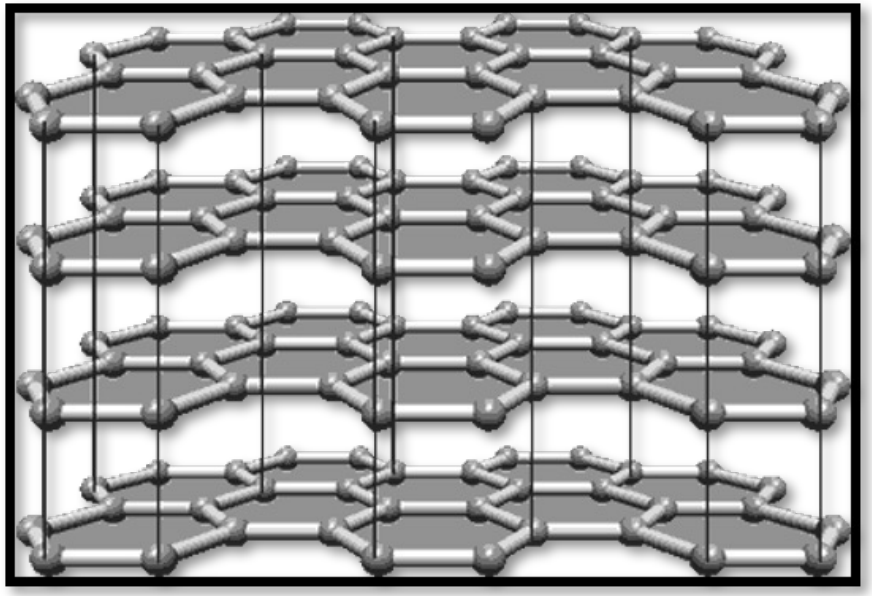
Graphene

- Monolayer of graphite

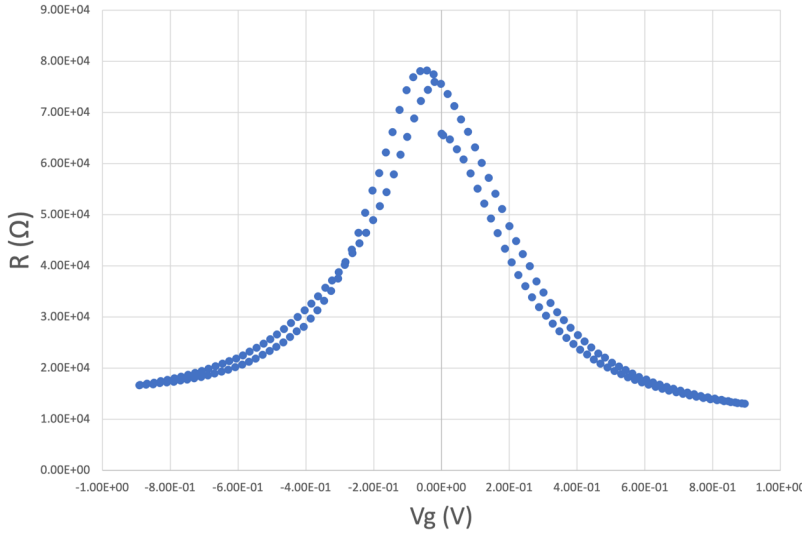


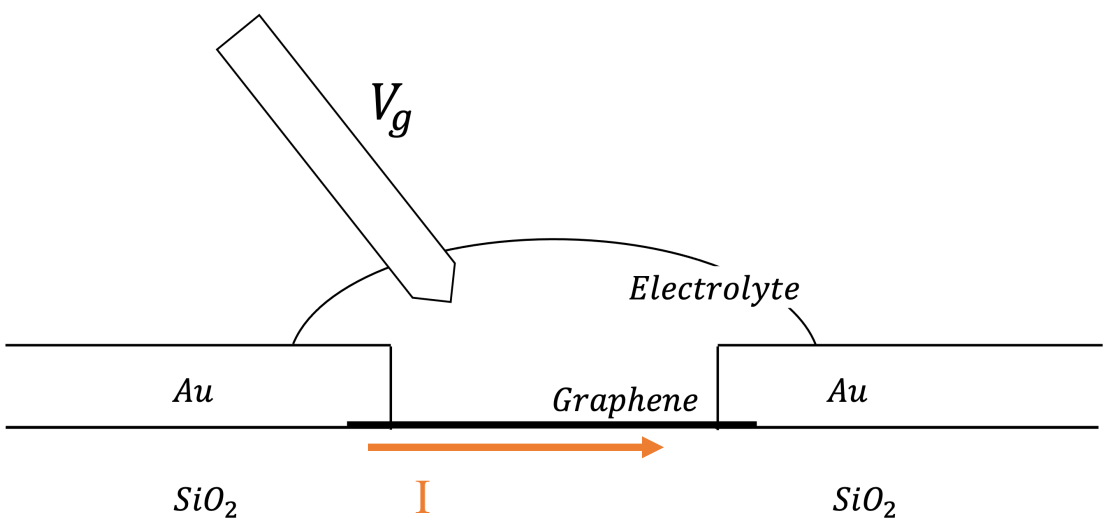


GRAPHENE!

Graphene

- Monolayer of graphite
- Resistance can change with an external voltage
- Thus, useful as a biosensor





Graphene

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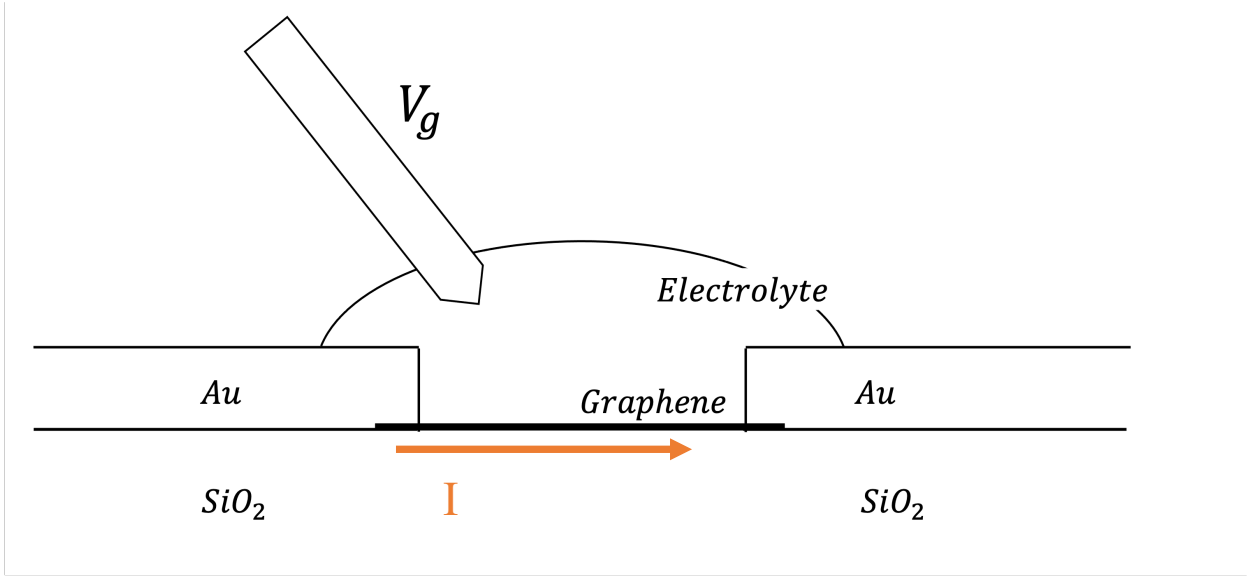
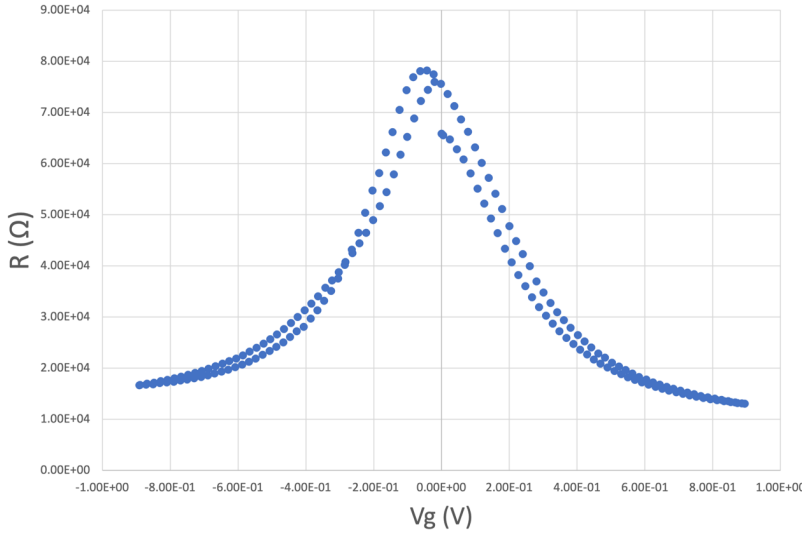
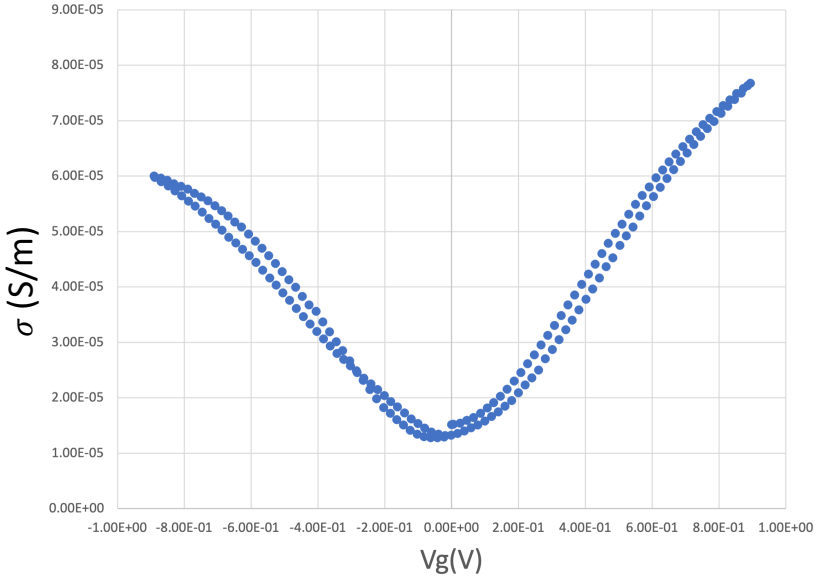
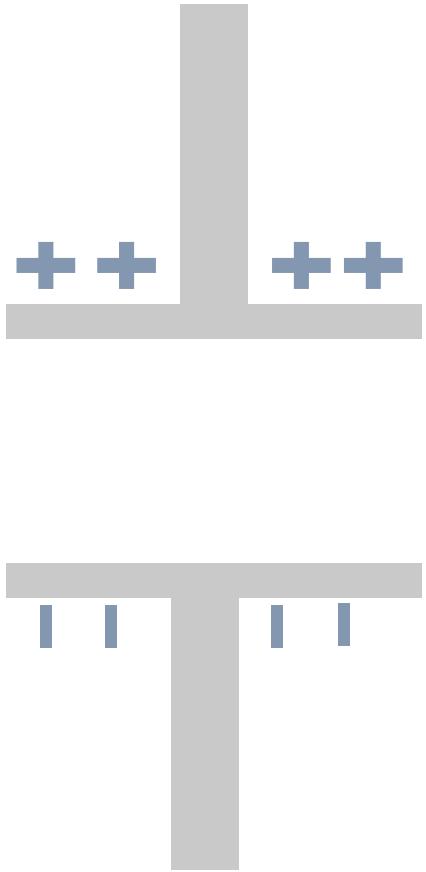






Capacitance

- Capacitance exists whenever there is a separation of charge



$$C = \frac{\kappa \epsilon A}{d}$$

Capacitance

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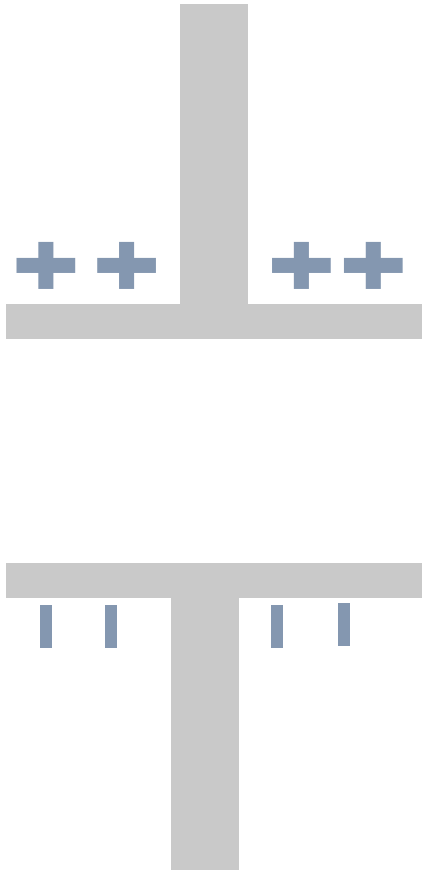
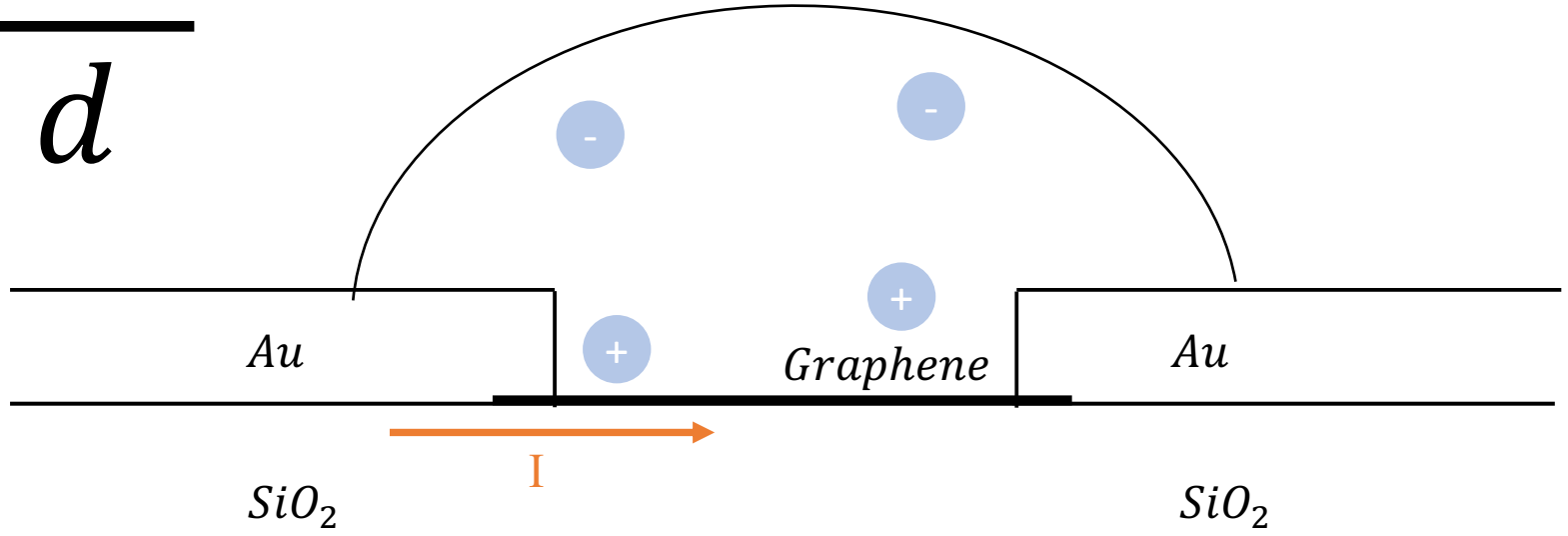


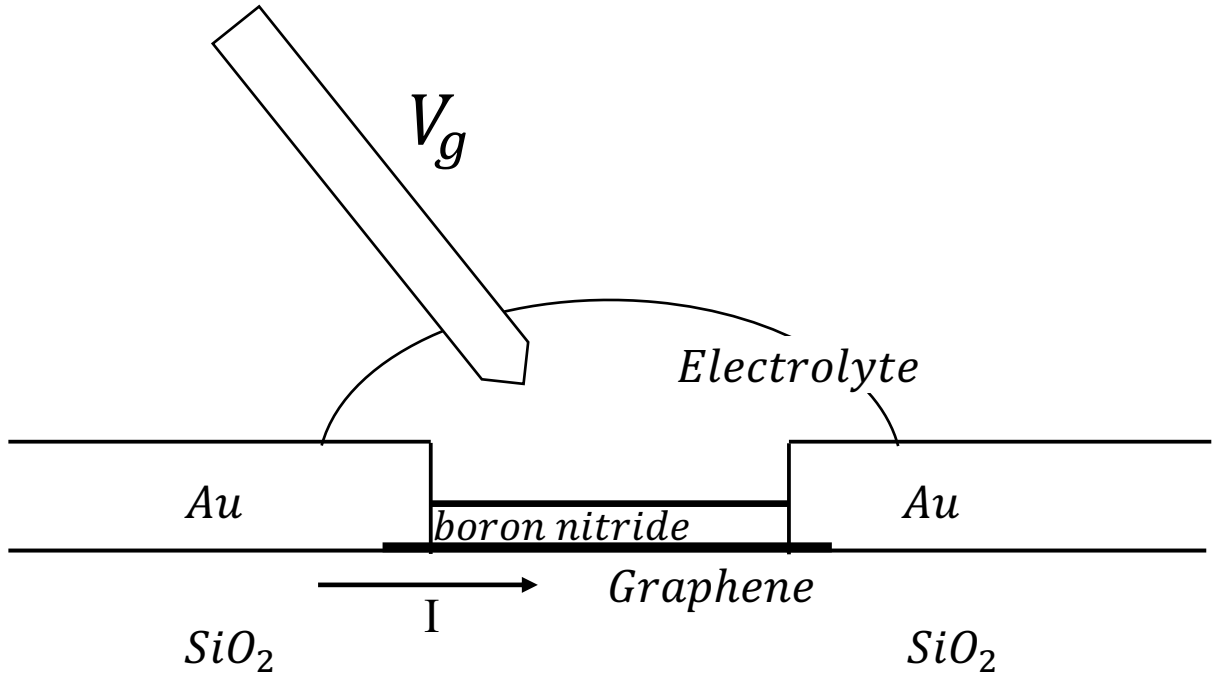
$$C = \frac{\kappa \epsilon A}{d}$$

- In a graphene biosensor, have a separation of charge
  - Ions in fluid can't cross into graphene
  - We have C but weird C



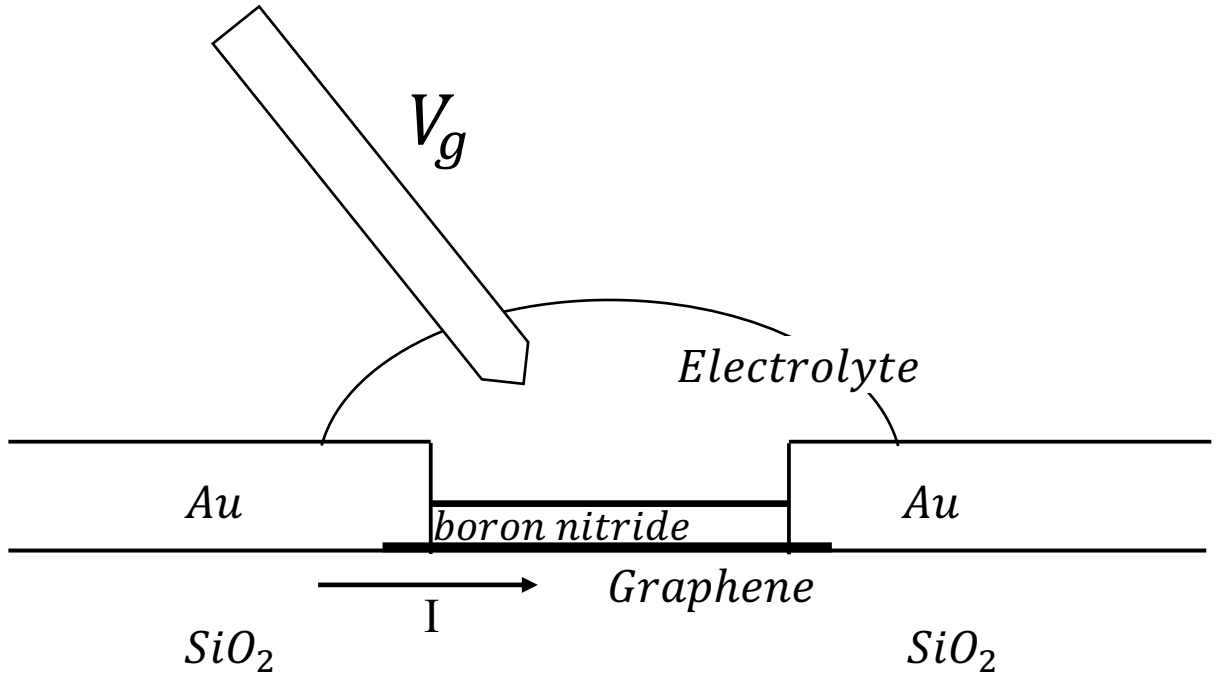
Boron Nitride

- Electrons can tunnel across
- This will change C, so gets noise



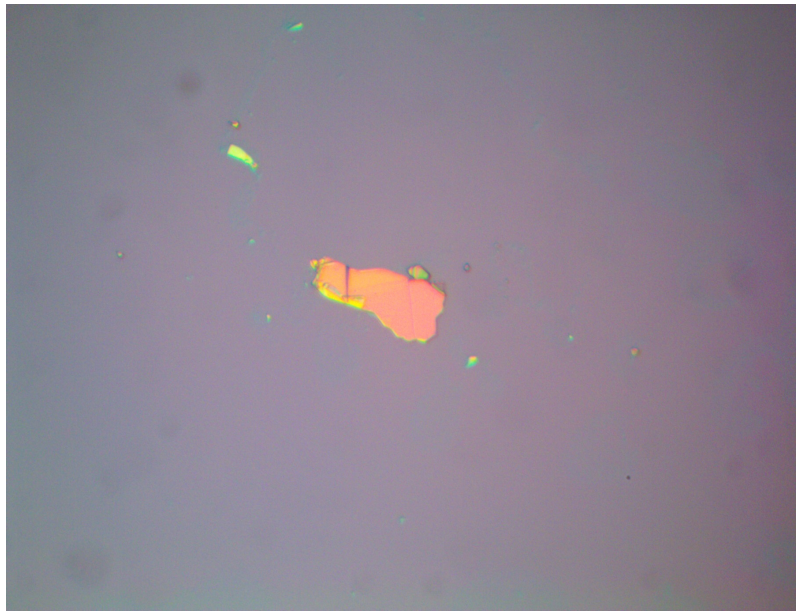
Boron Nitride

- Electrons can tunnel across
- This will change C, so gets noise
- We want to use an insulator to make C constant
- Boron nitride can be very thin

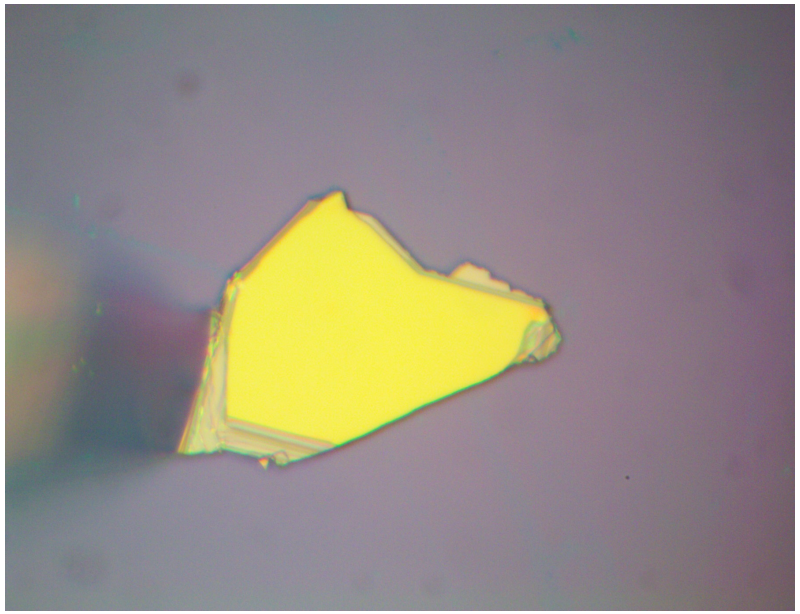


Boron Nitride

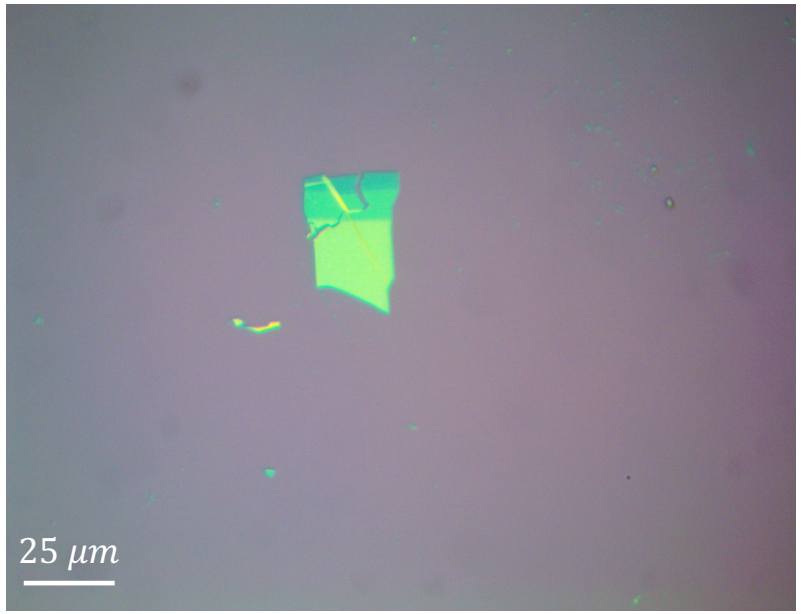
~ 60 and above



~ 25 – 60 nm



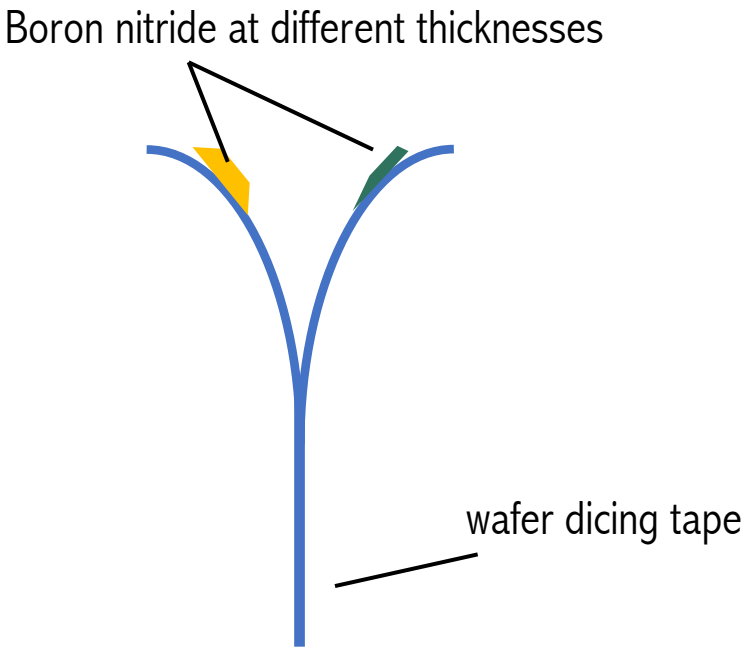
~ 15 - 25 nm

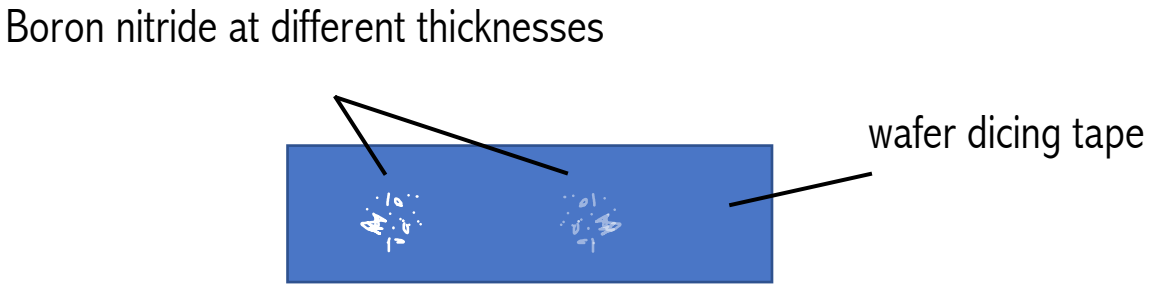


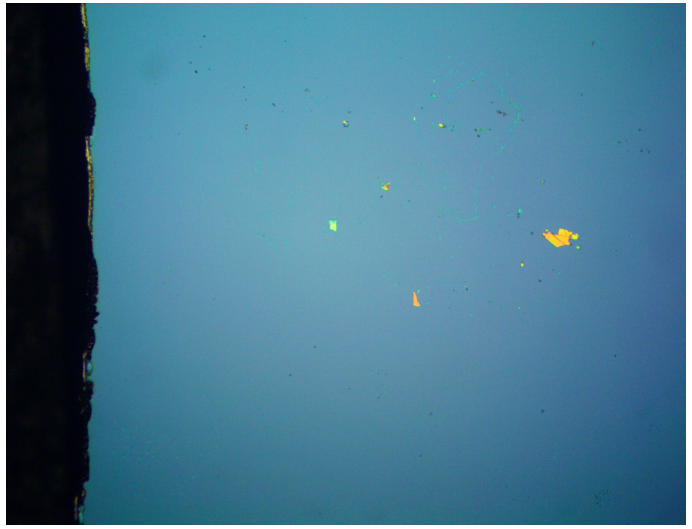
How to make hBN

Mechanical Exfoliation

- Exfoliate 4-5 times
- Transfer to SiO_2 wafer

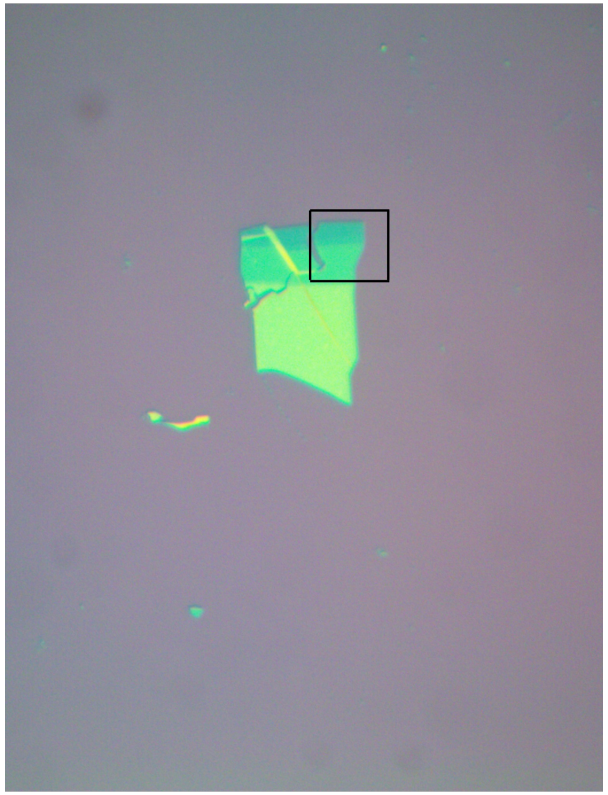


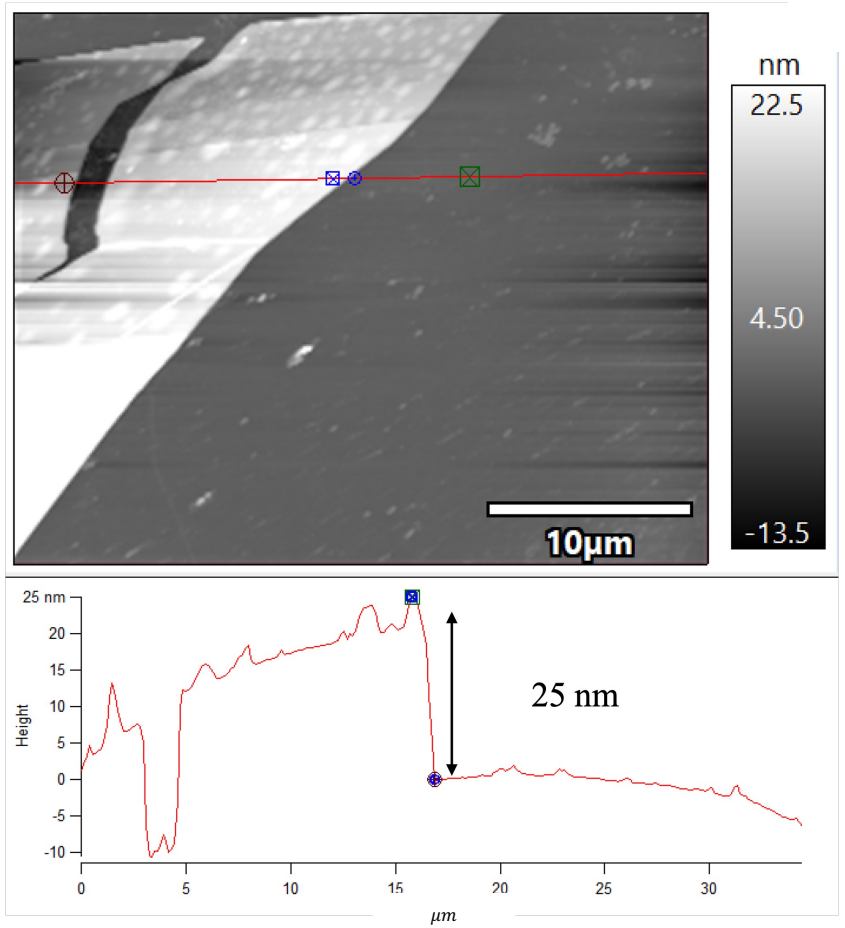




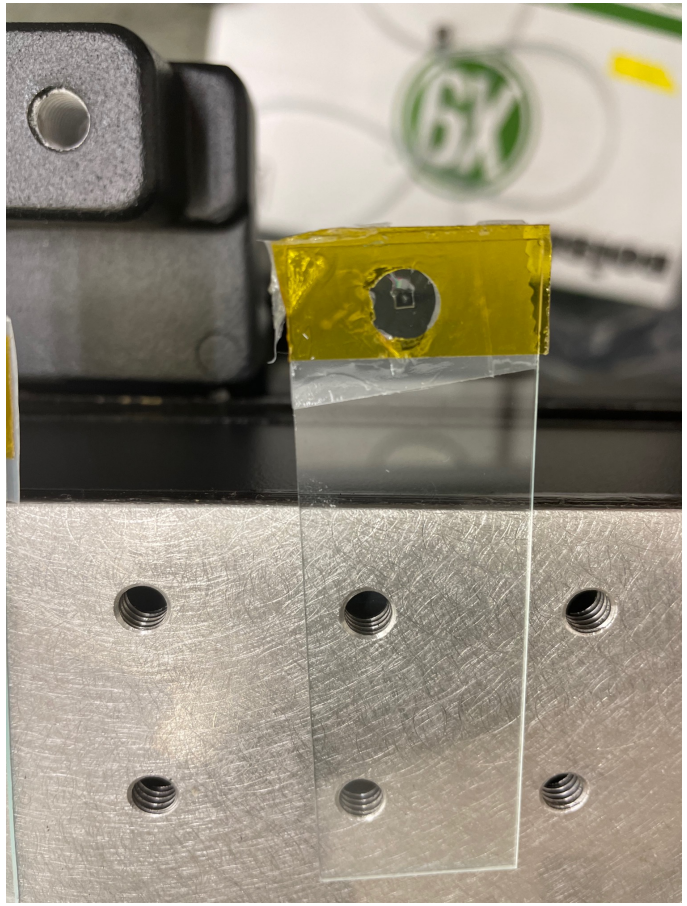
Boron Nitride

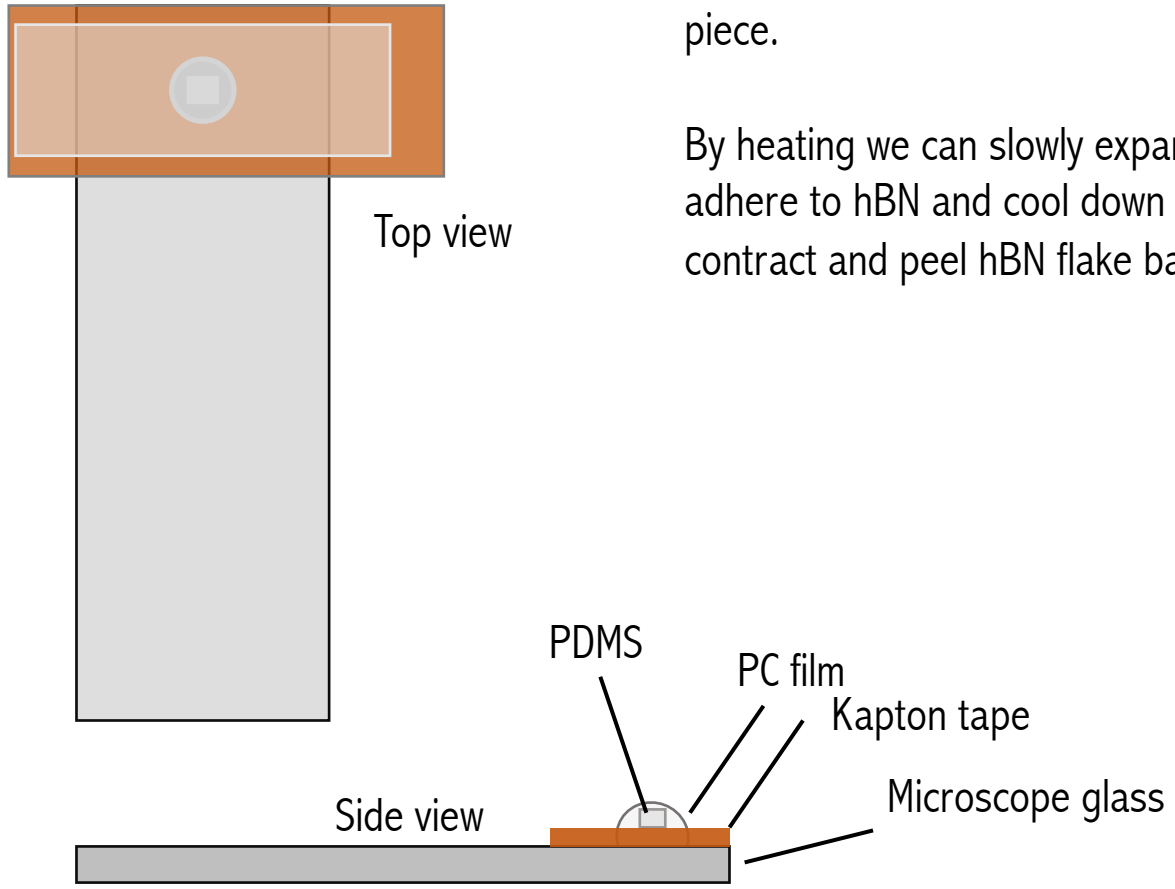
- Visually finding a flake that looks like the height we want
- Wanted height ~25 nm
- Use AFM to confirm thickness





PDMS Stamps



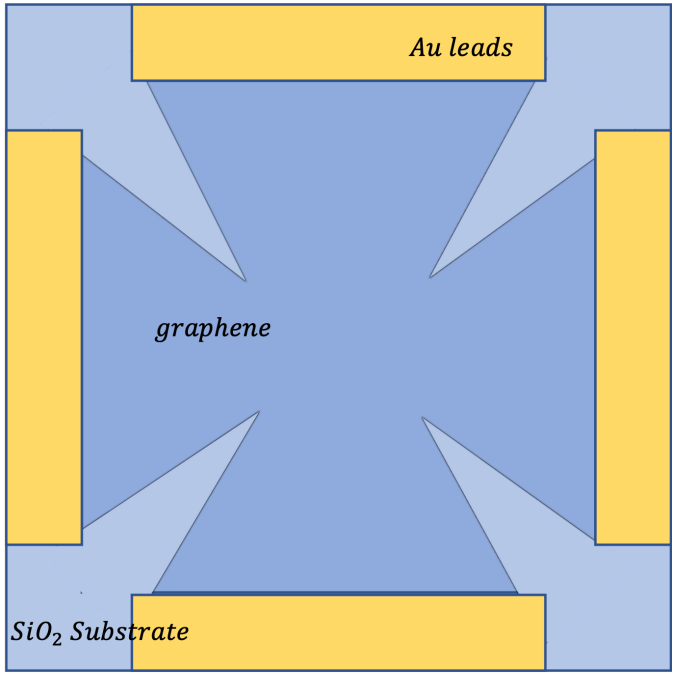


We can use the PDMS stamps to transfer boron nitride flakes on top of the graphene piece.

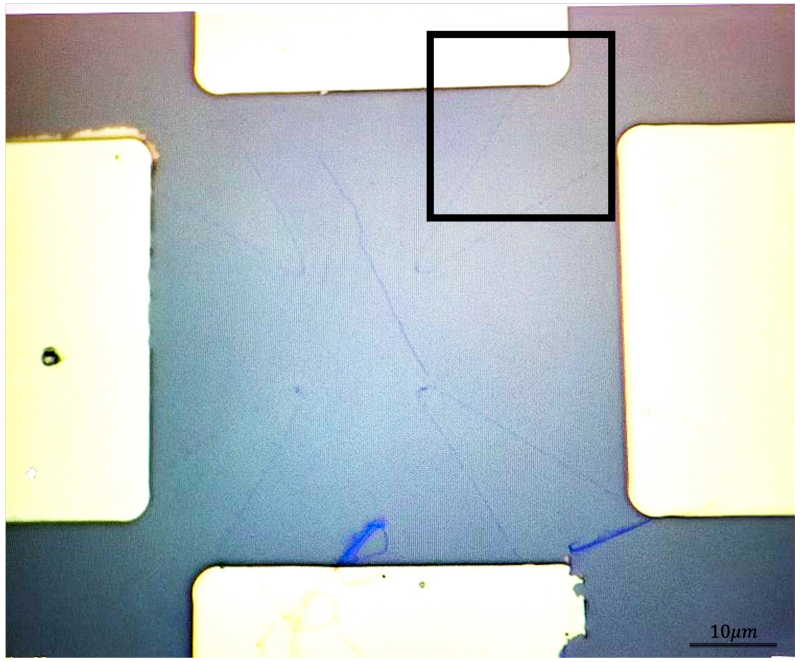
By heating we can slowly expand the PC to adhere to hBN and cool down to slowly contract and peel hBN flake back.

Graphene

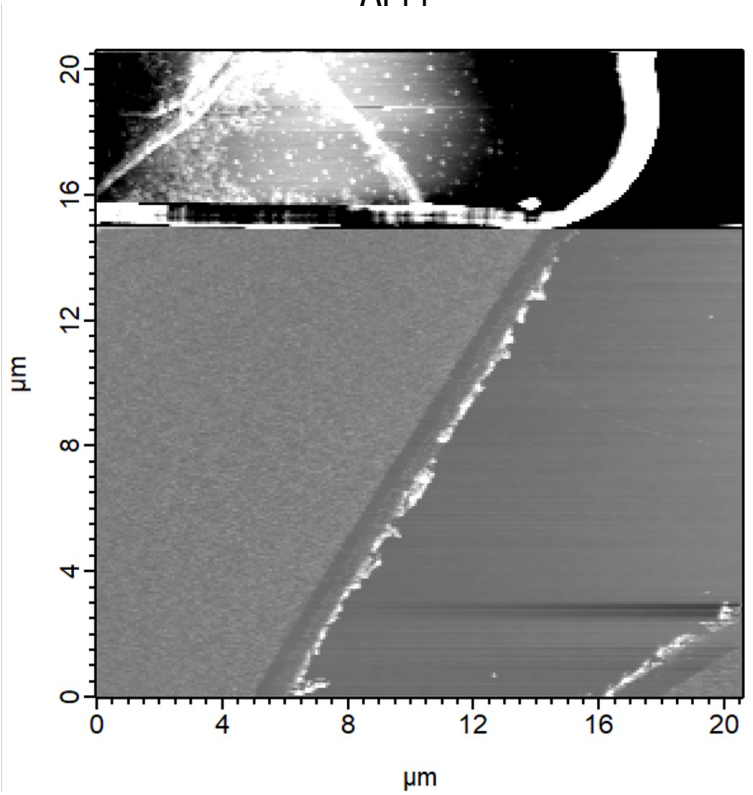
van der Pauw design



optical



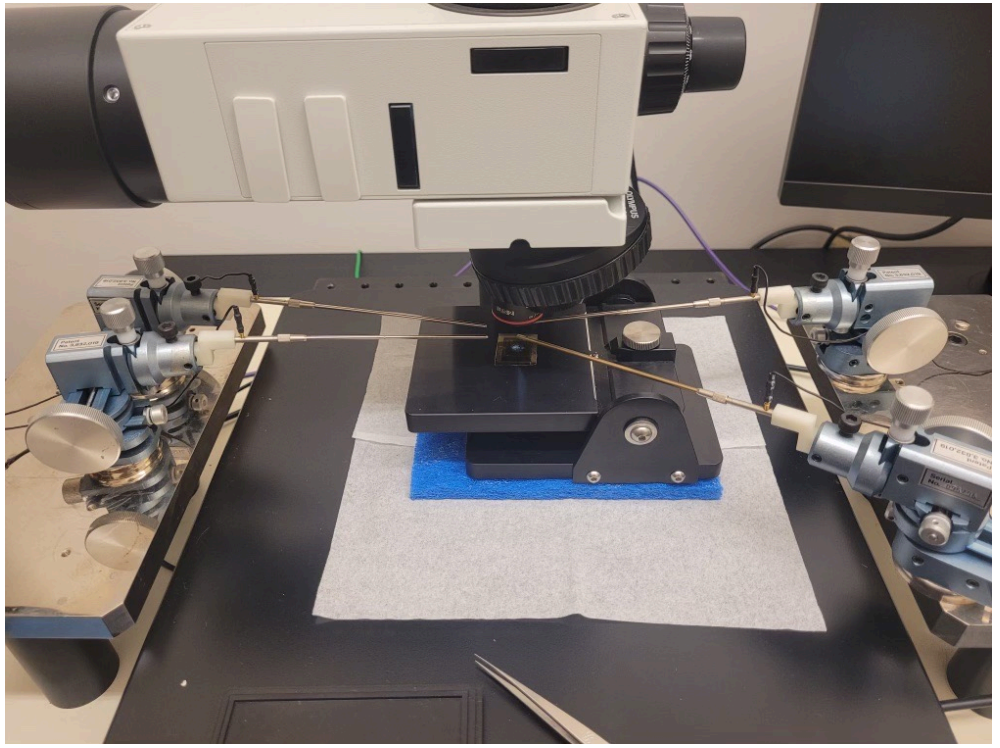
AFM

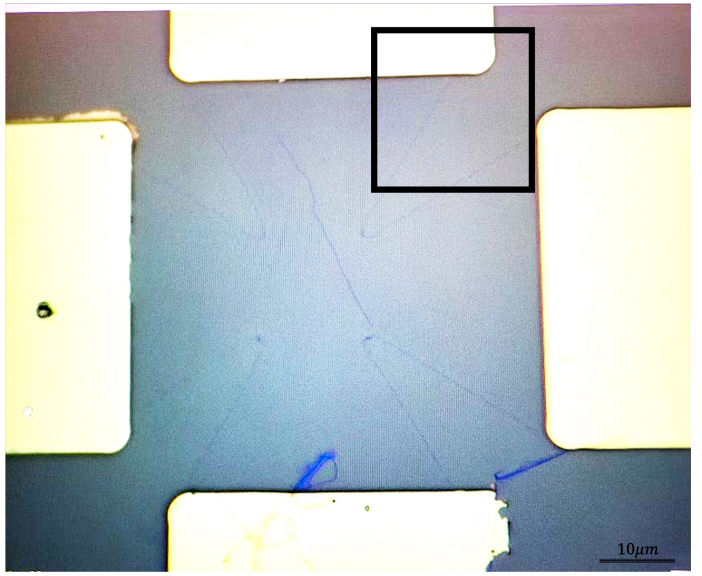


Experimental station

Lock-in amplifier

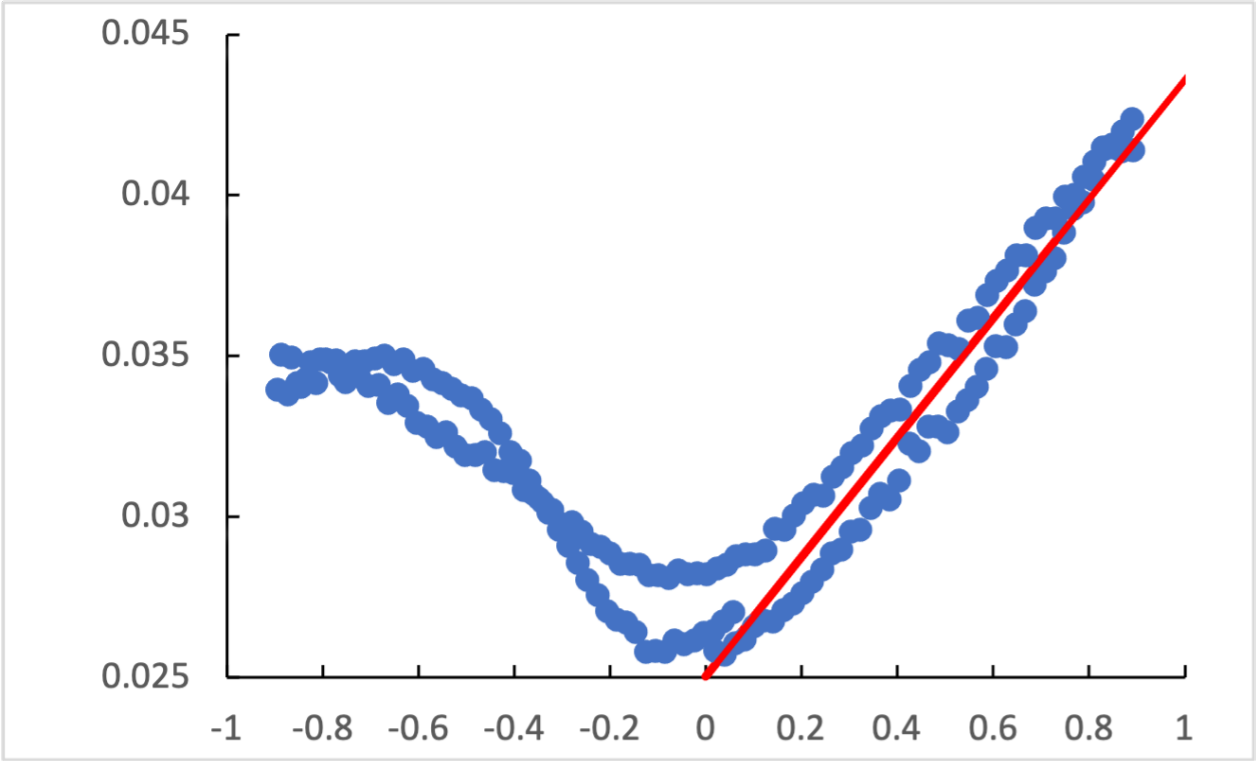
Probe station





Results

- AFM images
- 2 probe vs 4 probe
- Mobility, μ, measures quality of graphene
- $\mu = \frac{1000\ cm^2}{vs}$



Conclusions

What we've done

- Successfully mechanically exfoliated hBN
- Made PDMS stamps to transfer hBN
- We can graphene devices
- Set up measurements to measure graphene devices

What we plan to do

- Measure the interface capacitance
- Add hBN to sample and measure

Thank you!

Thank you to

- the National Science Foundation for funding me on this project.
- Linfield University
  - Dr. Michael Crosser, Conner Dooley,
- Oregon State University
  - Dublin Nichols, and Ethan Minot

Questions?

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