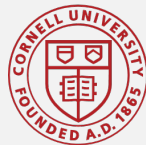


Piezoelectric RF SAW-based Energy Detectors

Daniel Teal
Mech. Eng. & Math, UT Austin

Dr. Amit Lal, Alex Ruyack,
SonicMEMS Lab, Cornell



Cornell
University

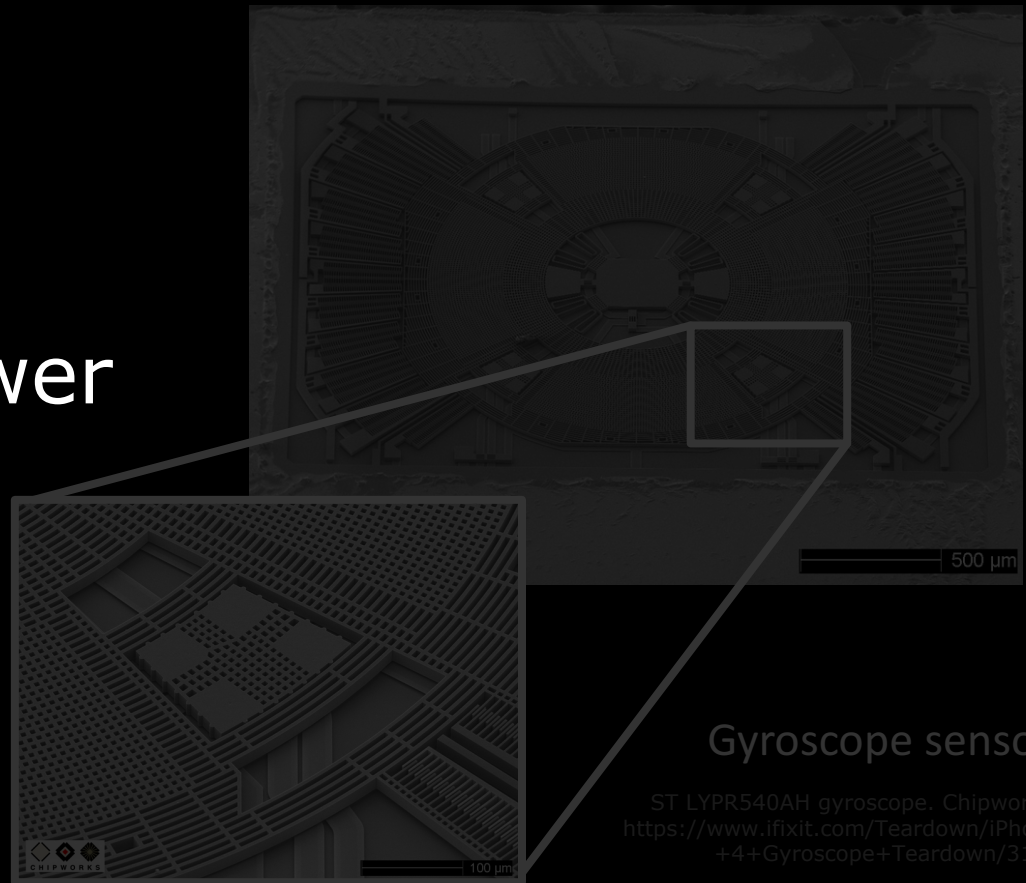


Novel Electronics

Different materials, physics, ideas

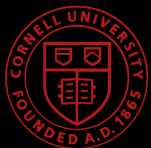


- New devices
- Sensors
- Very low power



Gyroscope sensor

ST LYPR540AH gyroscope, Chipworks.
<https://www.ifixit.com/Teardown/iPhone+4+Gyroscope+Teardown/3156>



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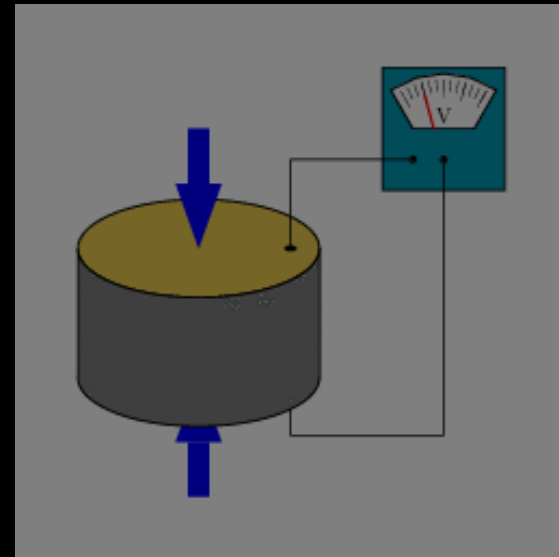
Piezoelectric Effect

Mechanical strain \leftrightarrow electric field
(due to crystal structure asymmetry)

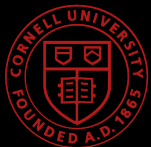


tuning fork quartz
resonator from a watch

Chribbe76, "Inside QuartzCrystal-Tuningfork",
Wikimedia Commons, 30 Dec 2007.



Tizeff, "SchemaPiezo", Wikimedia Commons,
22 Oct 2007.



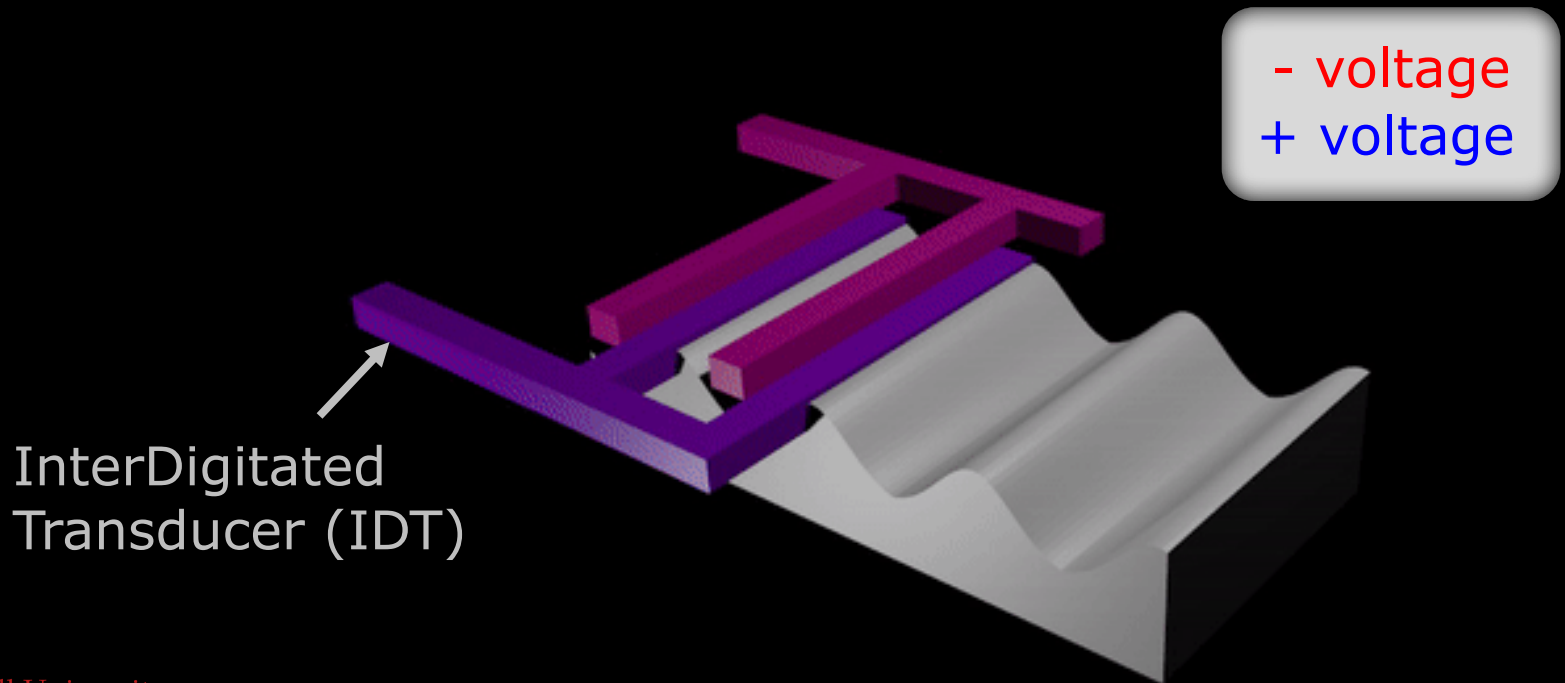
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Surface Acoustic Wave

alternating electric charge

→ alternating mechanical strain

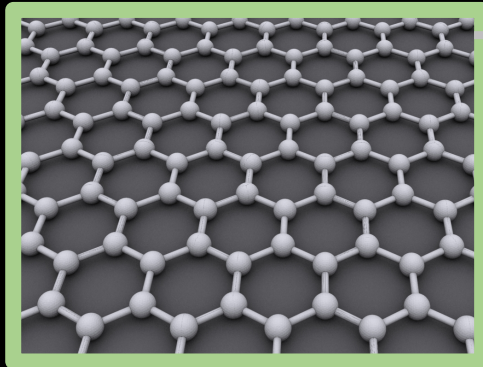
→ wave



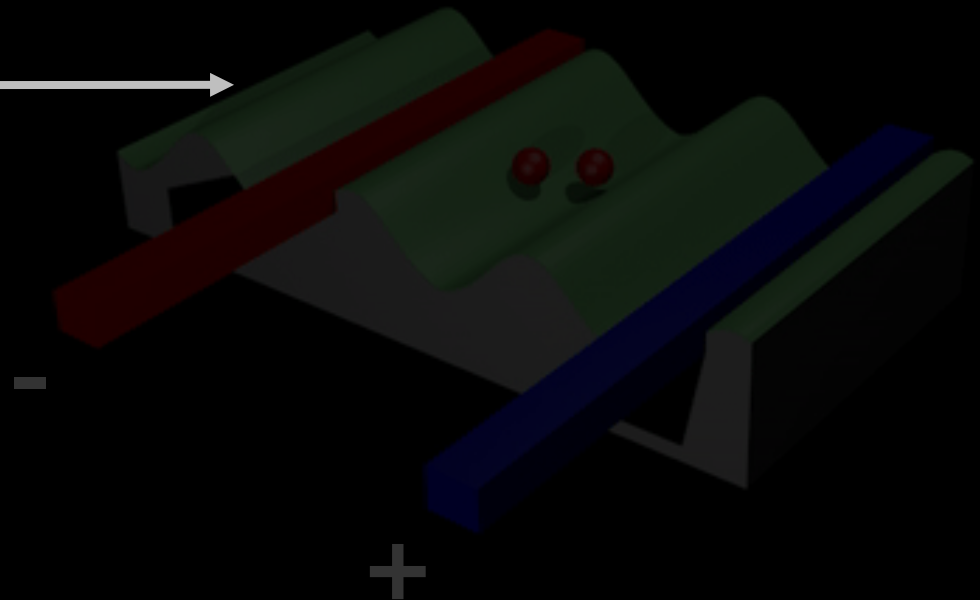
Acoustoelectric Effect

- Add graphene so charges can move
- Charges (electrons) pushed by electrically charged wave
- Steady, direct current

Graphene



AlexanderAIUS, "Graphen". Wikimedia Commons, 26 August 2010

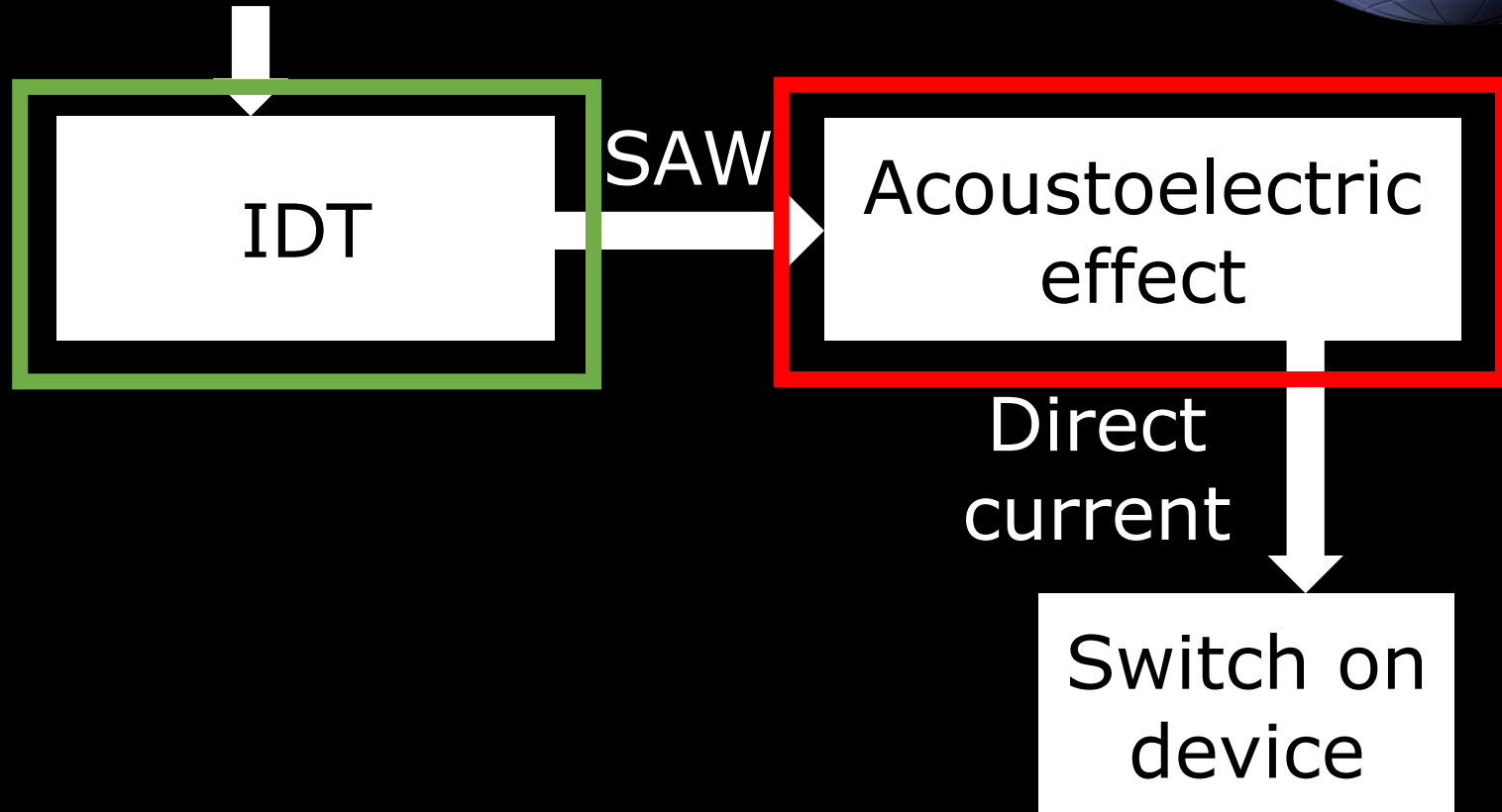


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Goal: Zero Power Sensor

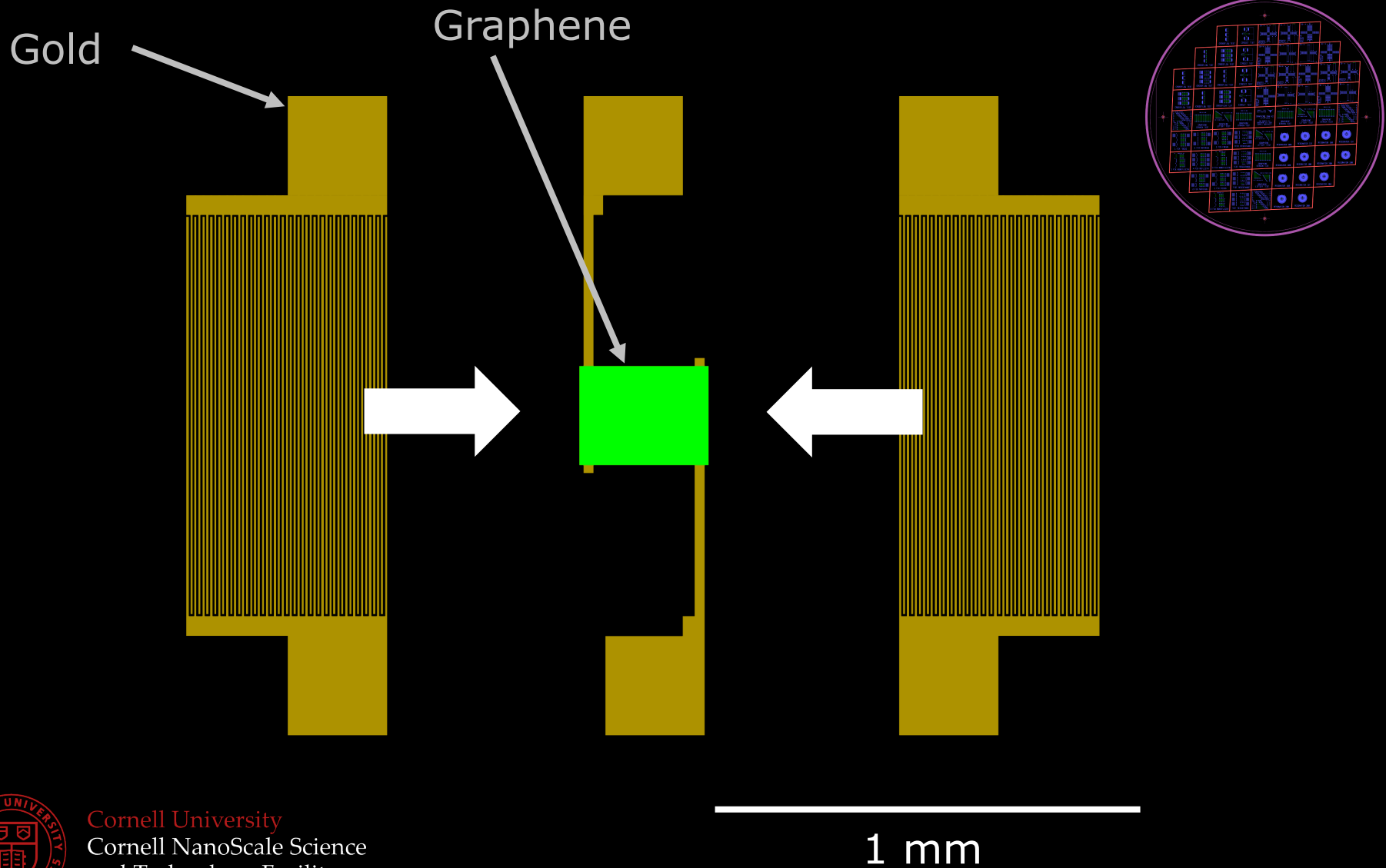


Radio wave (~ 2 microvolts)



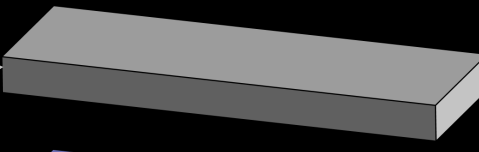
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Acoustoelectric Test



Manufacturing Process

Lithium Niobate

A 3D perspective view of a single, rectangular, light gray block representing a blank wafer.

1. Blank wafer

Negative Photoresist

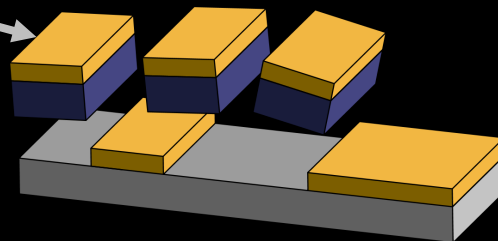
A 3D perspective view of the wafer with two rectangular blocks of dark blue photoresist on its surface.

2. Photoresist

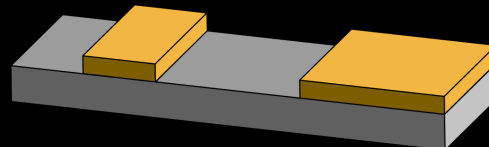
75 nm Gold +
10 nm Titanium
(adhesion layer)

A 3D perspective view of the wafer with the photoresist removed. It now has two rectangular blocks of yellow gold, each with a thin layer of blue titanium underneath.

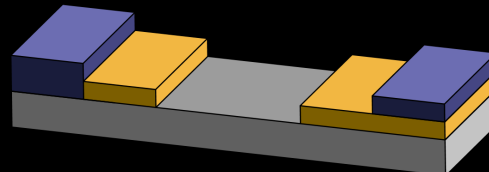
3. Evaporate gold



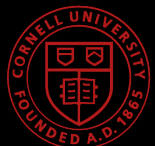
4. Lift off gold by
dissolving resist



5. Liftoff done

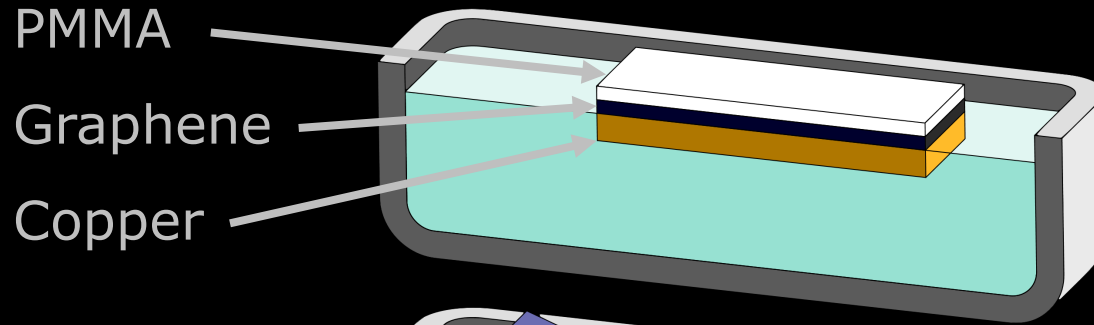


6. Photoresist

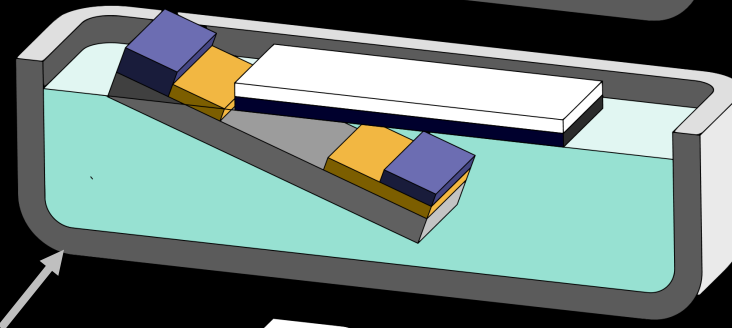


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Manufacturing Process

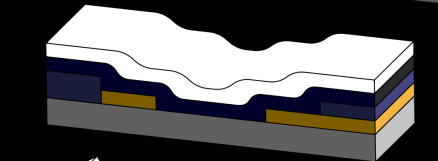


7. Dissolve copper

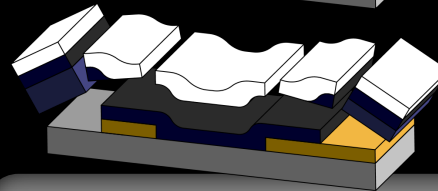


8. Transfer

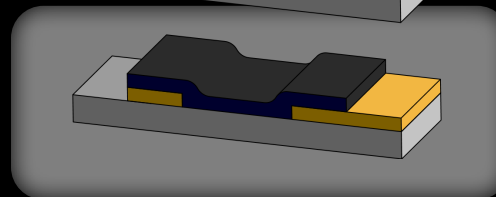
Copper etchant
(ferric chloride)



9. Transfer done



10. Lift off
graphene by
dissolving resist

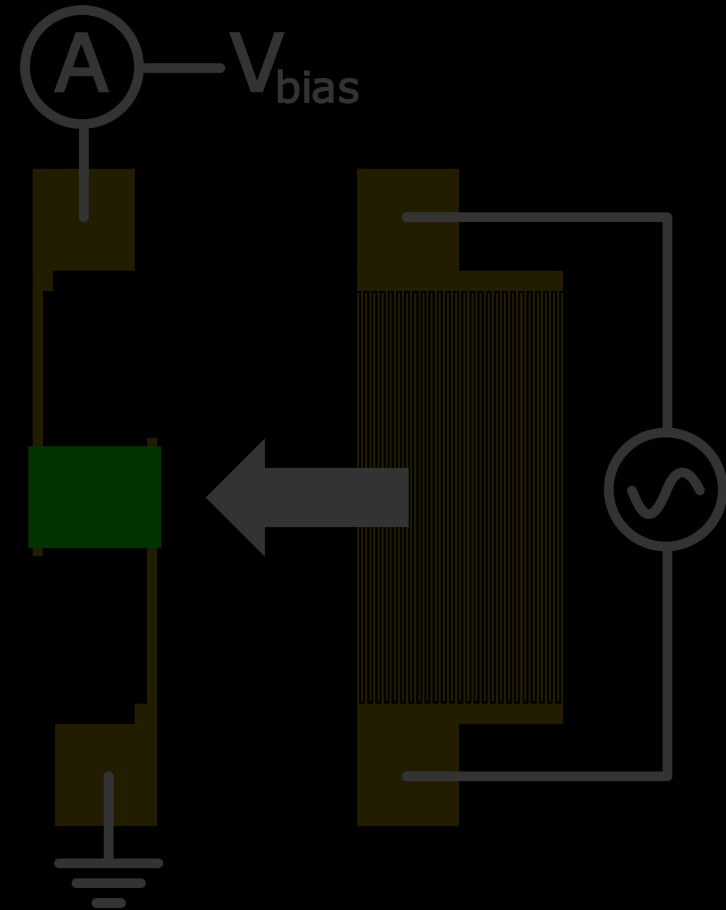
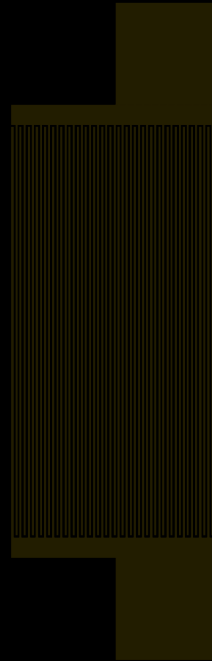
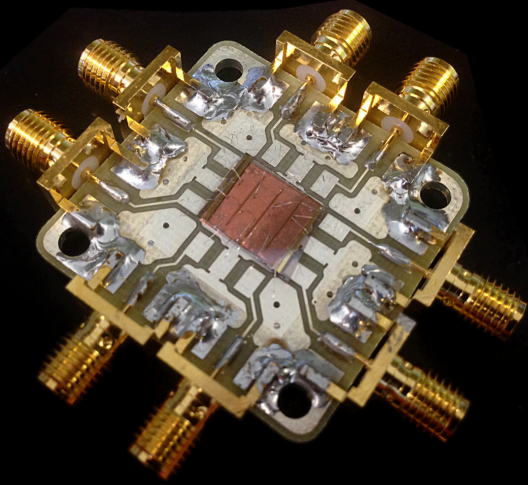
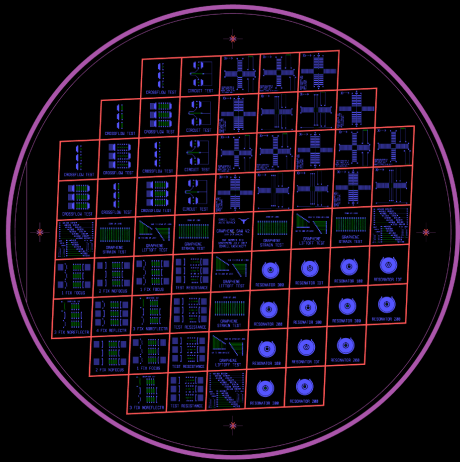


11. Done



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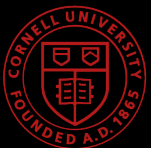
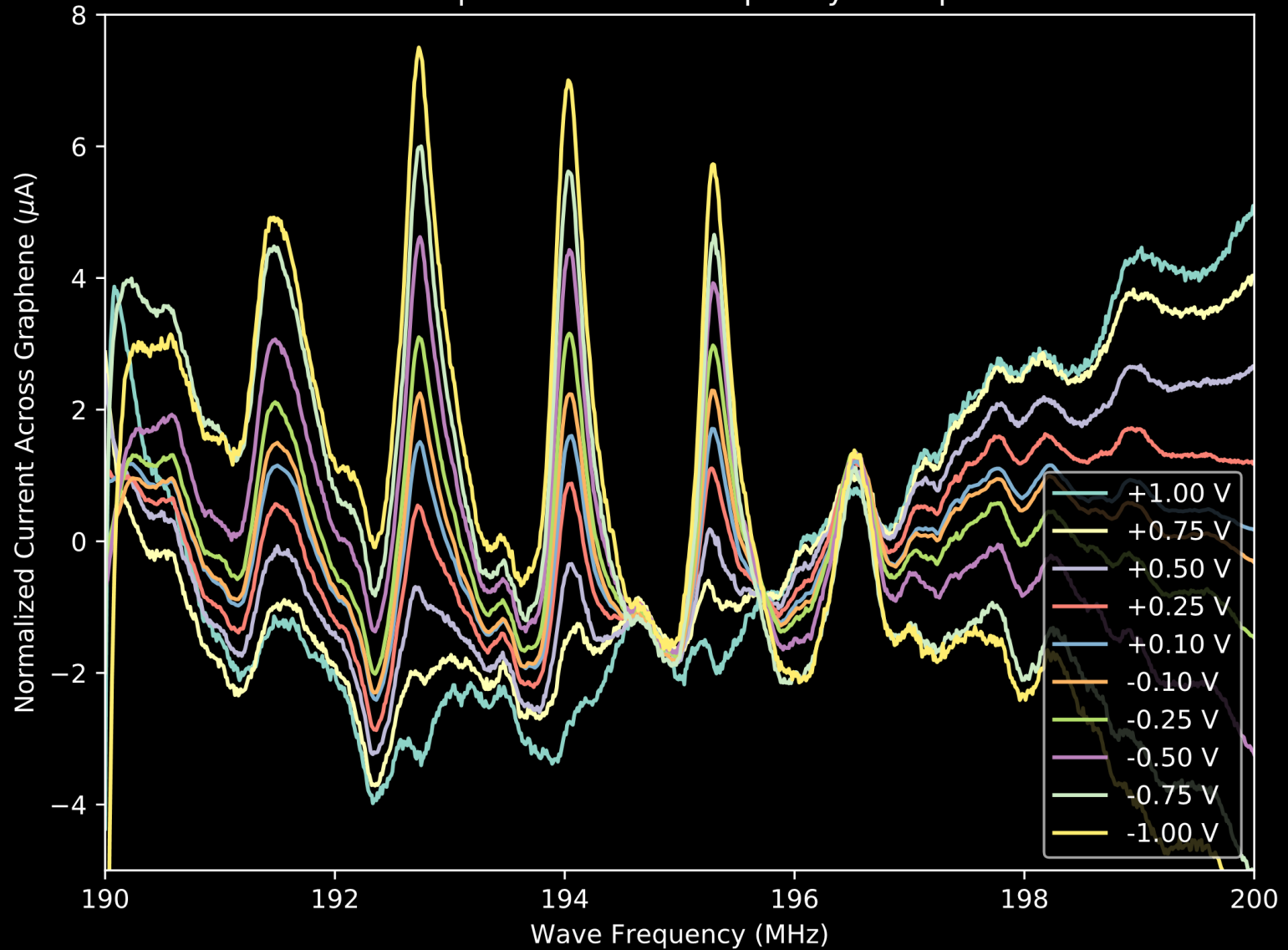
Testing Setup



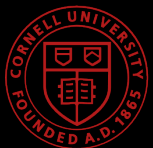
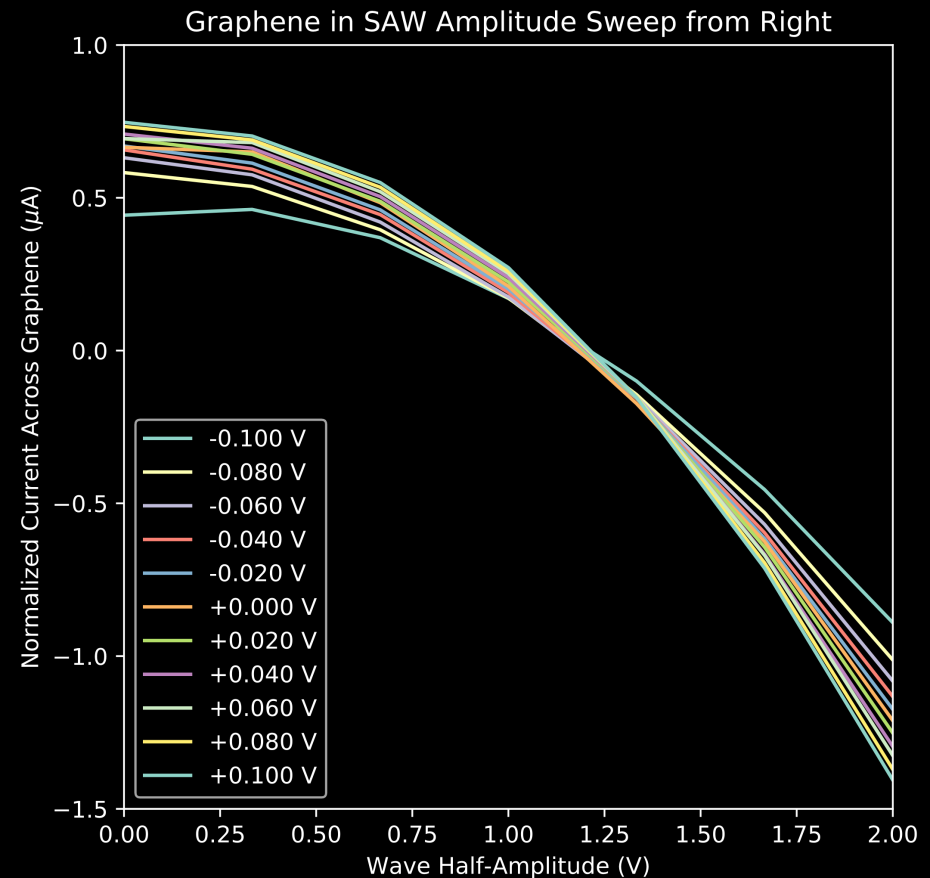
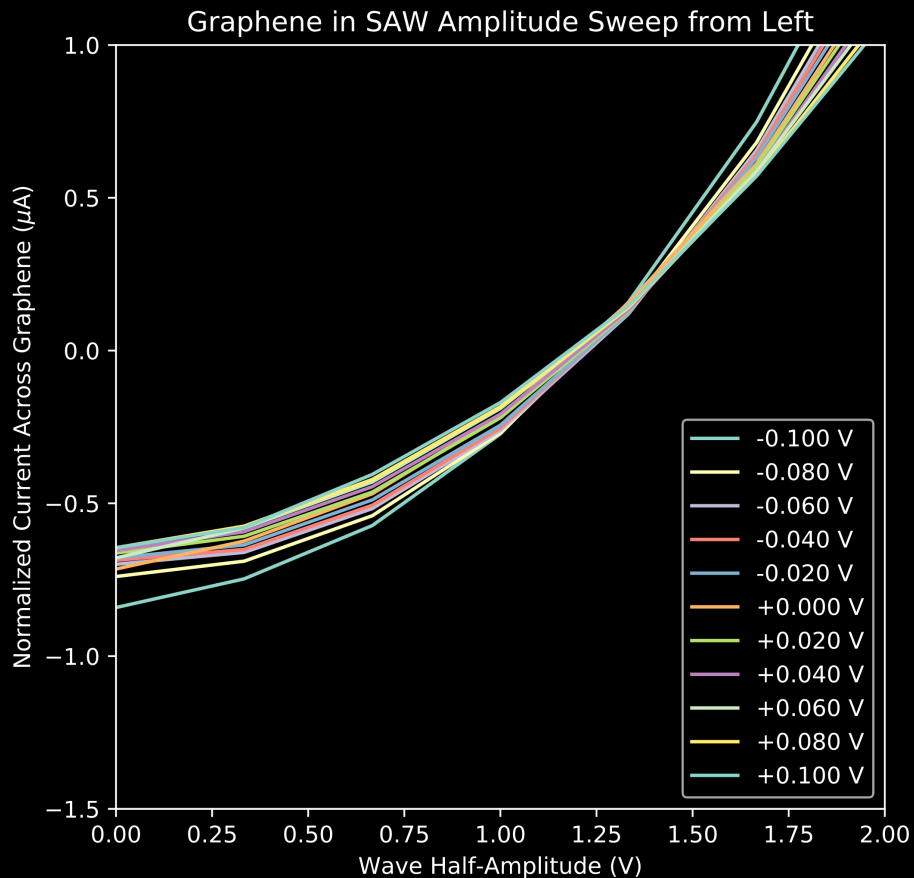
1 mm

1 mm

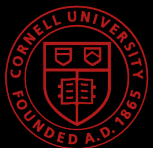
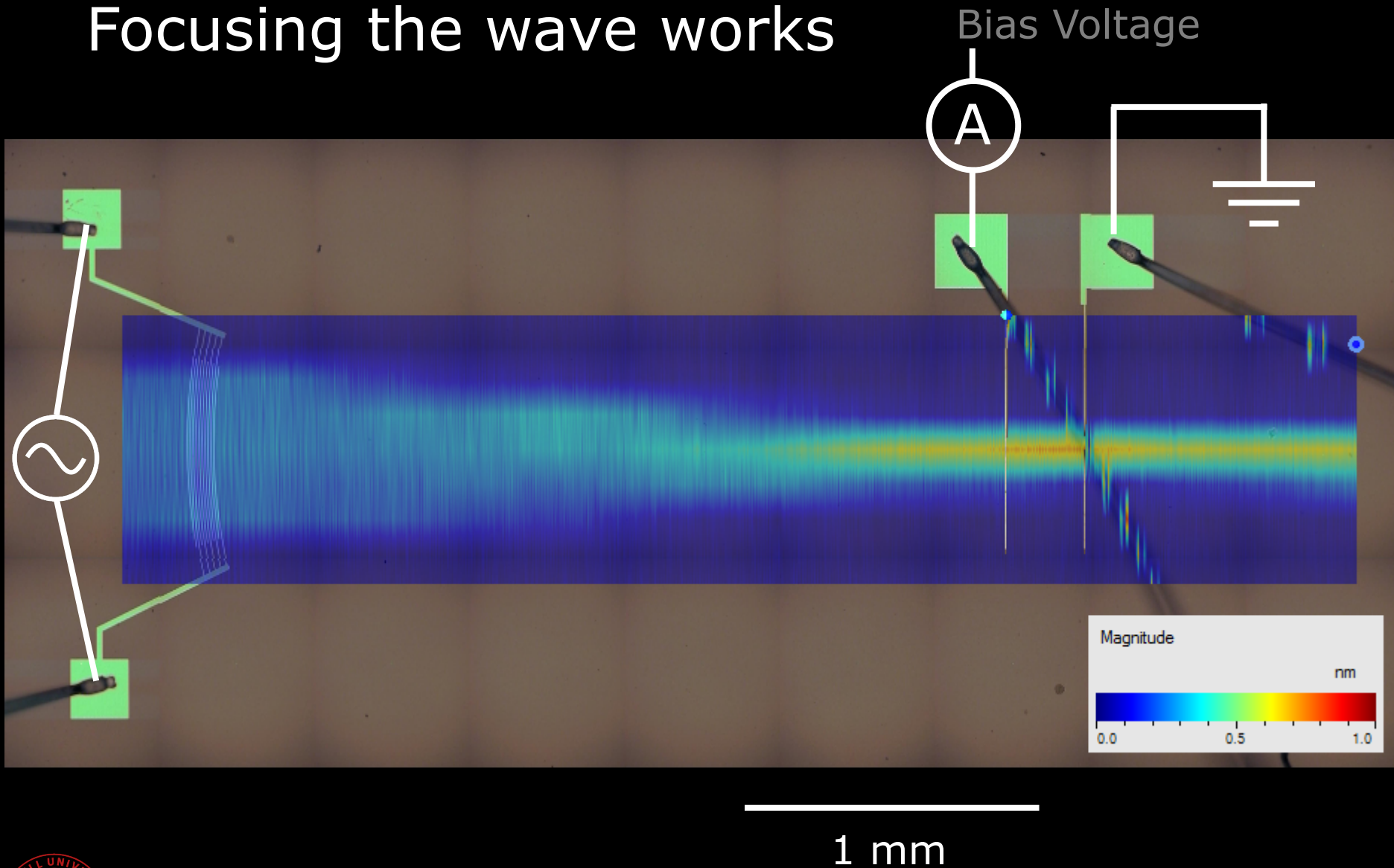
Graphene in SAW Frequency Sweep



Observe Acoustoelectric Effect

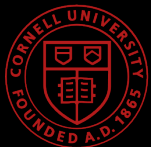


Focusing the wave works



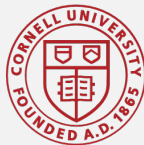
Conclusions

- Built device
 - Acoustoelectric effect generates current
 - Focuses SAW for easier control
 - Compatible with other devices in lab
- Future work: system integration
 - Zero-power sensor



Acknowledgements

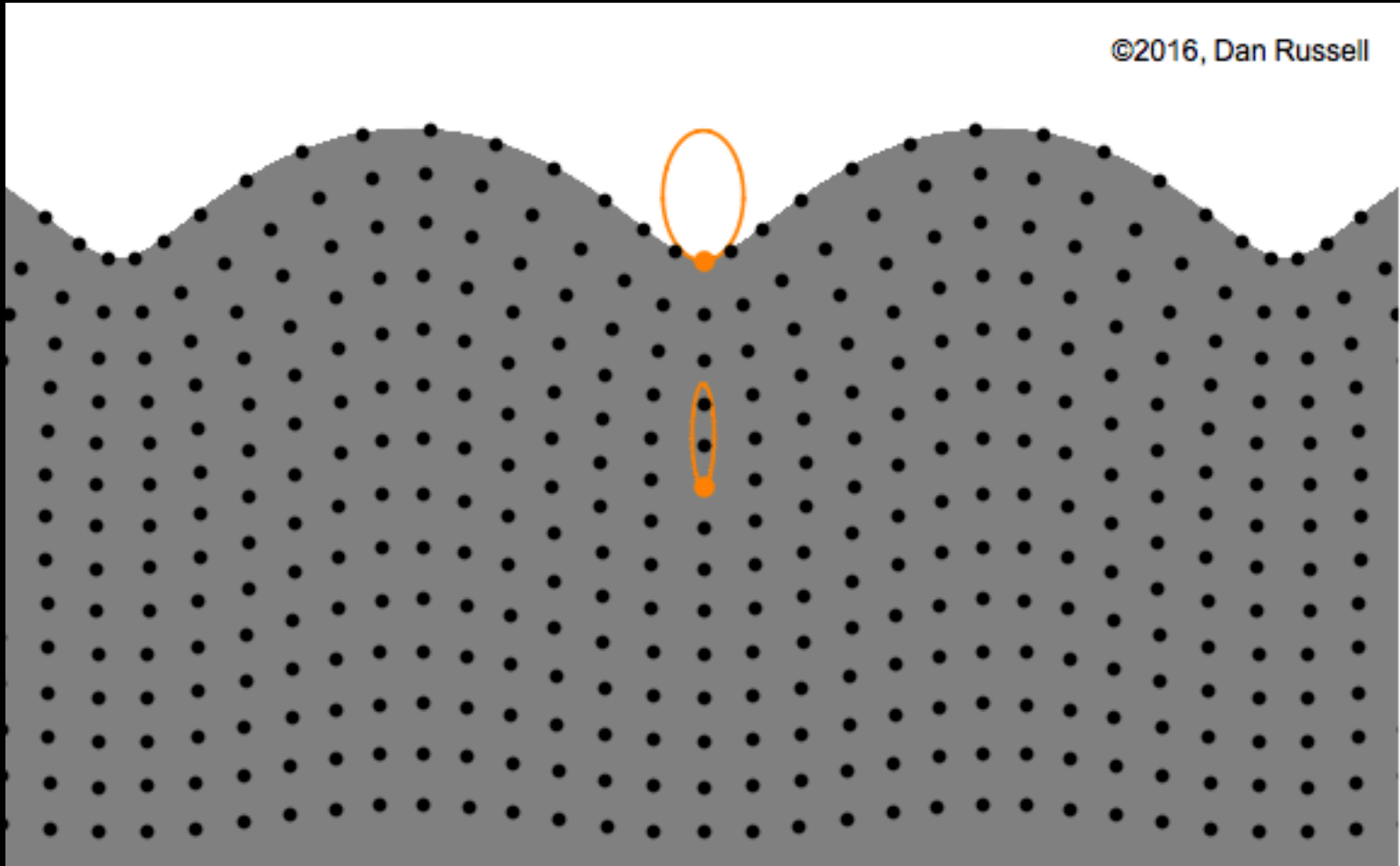
- National Science Foundation
- National Nanotechnology Coordinated Infrastructure
- Cornell NanoScale Science & Technology Facility
 - NSF grant no. ECCS-1542081
- PI: Dr. Amit Lal
- Mentors: Alex Ruyack & Benyamin Davaji, Nabil Shalabi
- CNF REU Program Coordinators
- CNF Staff, esp. Aaron, Jerry, Chris



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