SCANNING TUNNELING MICROSCOPE

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- INTRODUCTION
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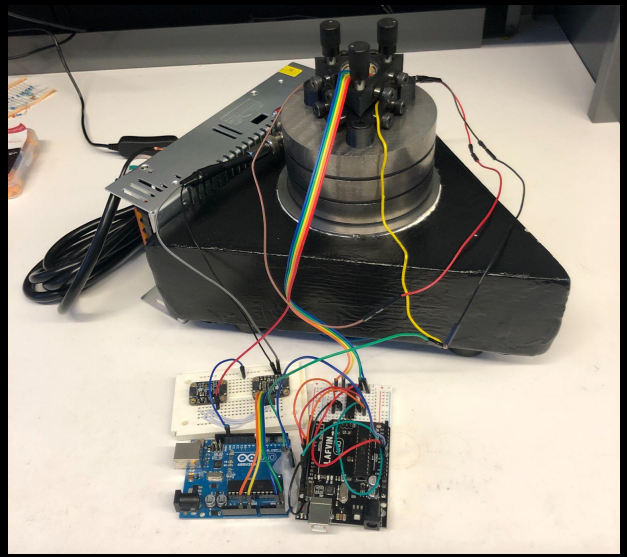
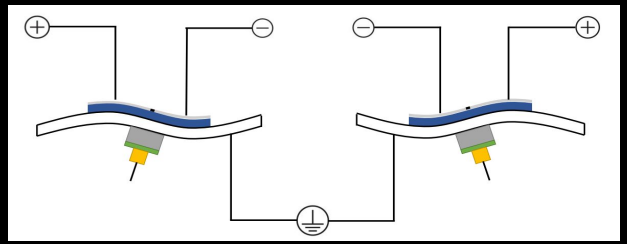


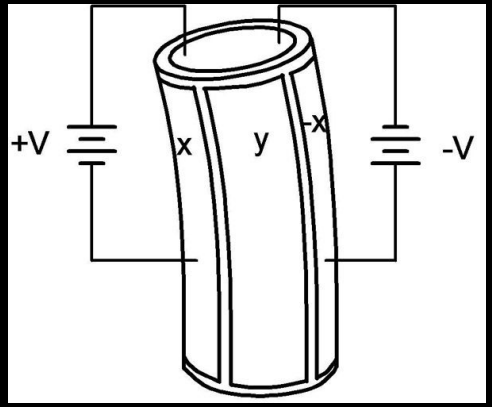


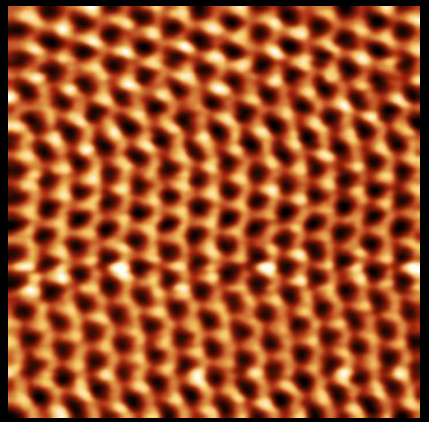
INTRODUCTION

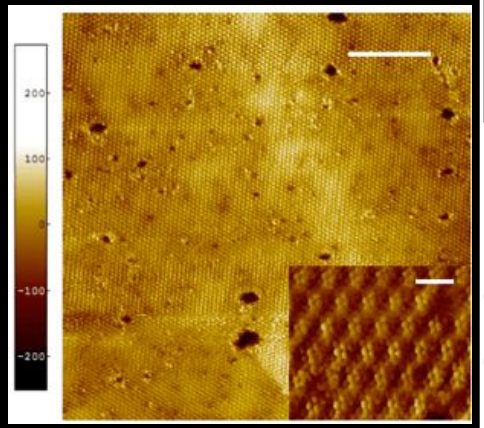
- STM - $10,000
- Large and power hungry
- Require other expensive and large equipment
- Incredibly useful tool for understanding atomic structures

METHODOLOGY

- Piezoelectric material
  - Tube vs disc
- Control system
  - Feedback loop vs. proprietary control system
- Cost and accessibility
  - $500 vs $10,000
- Overall performance
  - Resolution, image size







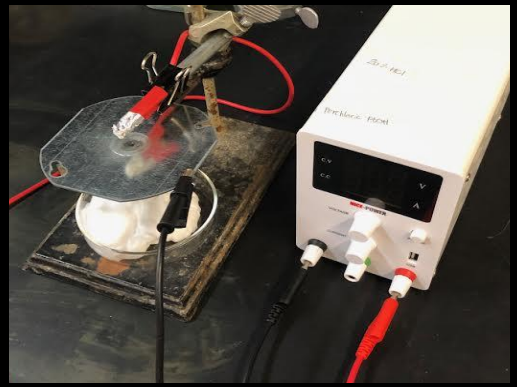
METHODOLOGY - Tip Etching

Resources:

- Tungsten Wire
- Shaving cream
- Sodium Hydroxide (NaOH)
- Isopropyl alcohol

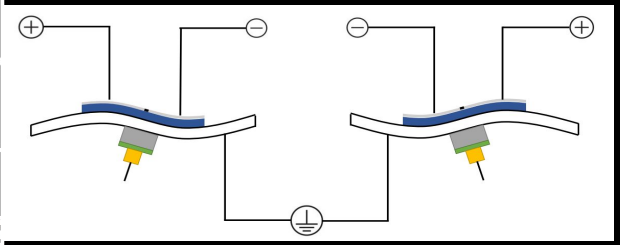
Impact:

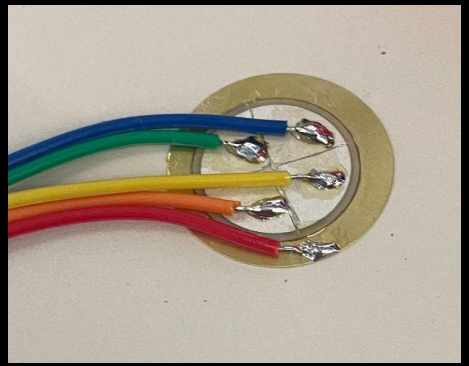
- Atomic sharpness
- Resolution & sensitivity

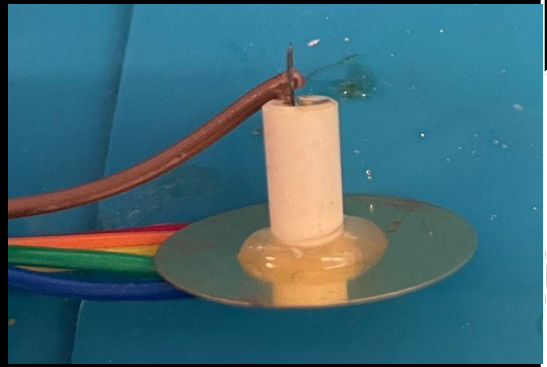


METHODOLOGY - Piezoelectric Disc

- Main mechanism for scanning the material
- Quadrants provide precise movement
- Allows for control of X, Y, and Z axes
- Responsible for holding the tip steady for measurements

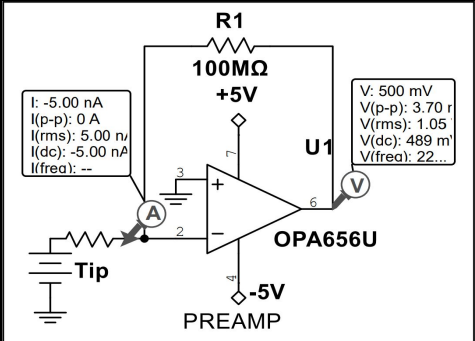






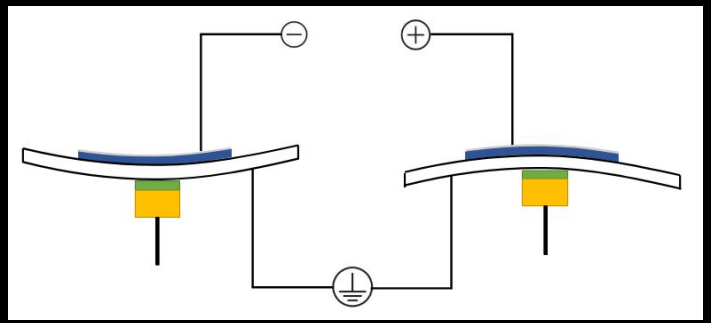
METHODOLOGY - Transimpedance Amp

- Expected tunneling current is in nA (10^{-9} A)
- T-Amp amplifies the tunneling current and outputs a voltage between 0v~2v
- Initially attempted a hardware design
- Ended up using a Thorlabs commercial T-Amp



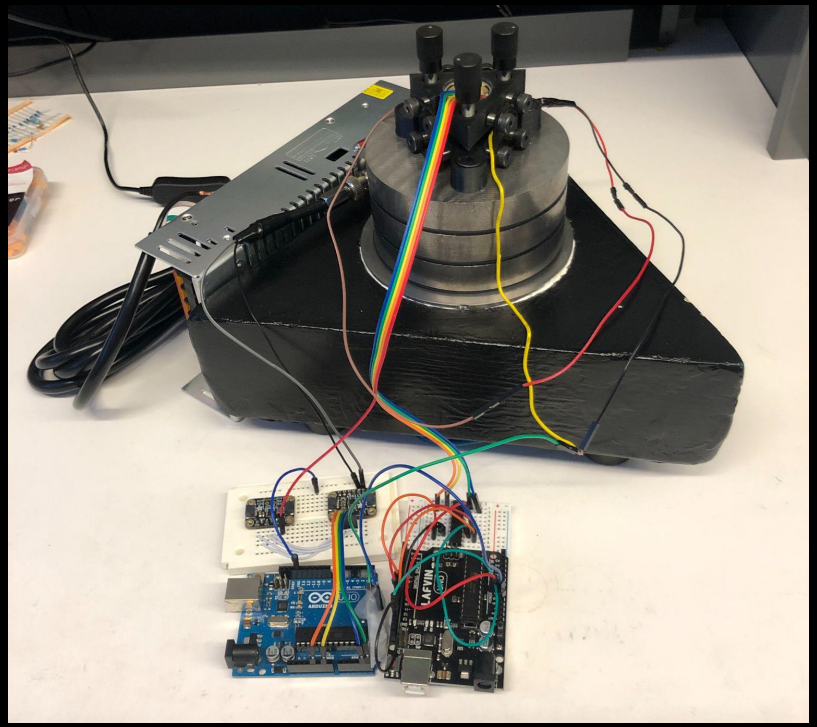
METHODOLOGY - Feedback Loop

- Utilizes the Z-axis bend of the piezo disc
- Increases precision and quality
- Prevents damage to the atomically sharp tip
- The team has been going back and forth on a hardware vs. software implementation
    - Flexibility & integration vs RT response & stability



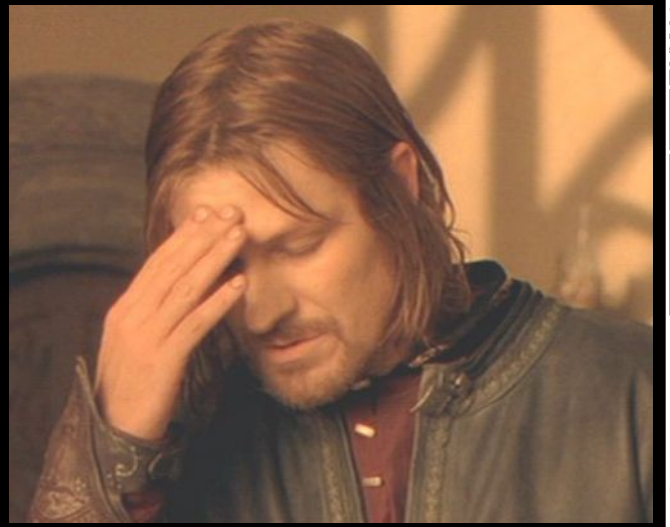
RESULTS

- Made a mechanical damping solution
- Consistent tunneling current
- Feedback loop
- Scanning process



CONCLUSION - Lessons Learned

- Tried to make fully custom circuits rather than more expensive commercial options
- Troubleshooting a system is difficult and confusing
- We made the switch to a commercial T-Amp
- We wish we had started with more commercial products
- Result verification is not easy



CONCLUSION - Future Work

- Scanning an image with the piezo disc
  - Implementation of the piezo driver circuit
- Data collection and processing
  - Image processing in software i.e. MATLAB
- Implementation of commercial products
  - Commercial feedback loop/PI controller