

Better, Smaller, Faster:  
MEMS for Mechanotransduction  
and

The Importance of Being  
Scrappy

A close-up photograph of a chipmunk with brown, white, and black stripes, standing on a rough, textured tree trunk. The chipmunk is looking down and to the left. The background is a clear, bright blue sky.

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# Migrating South, Slowly





# Nearby Fun

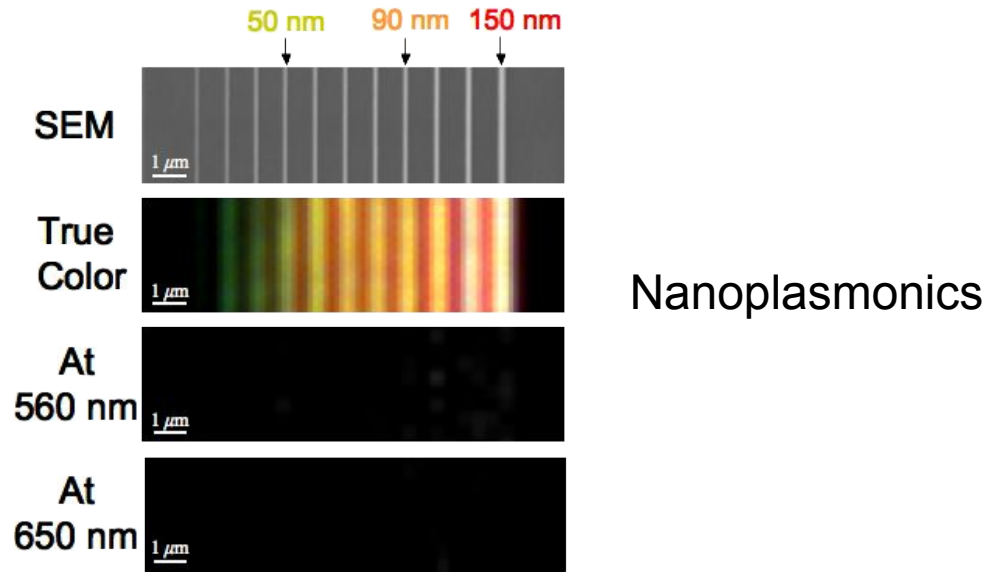


Backpacking in the Sierras



Canoeing on the Russian River

# Undergrad Projects



Metal Foam

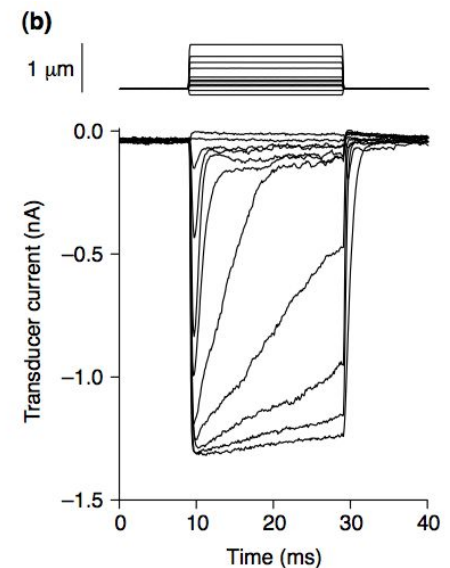
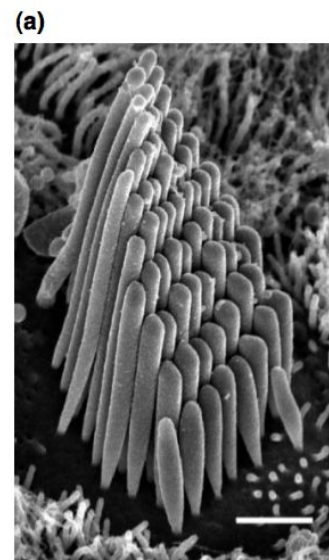
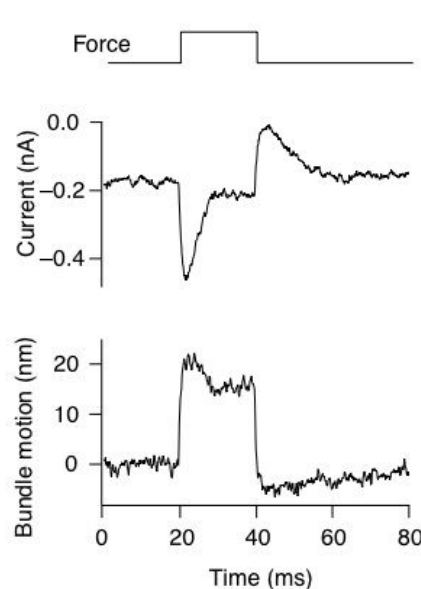
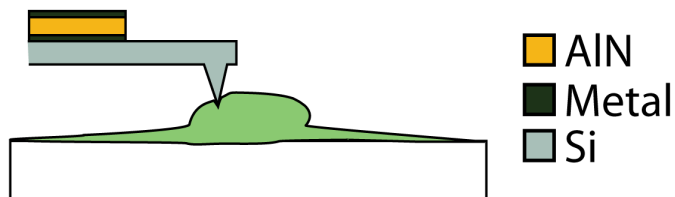


Senior Project: Mobile Fire Obliterator



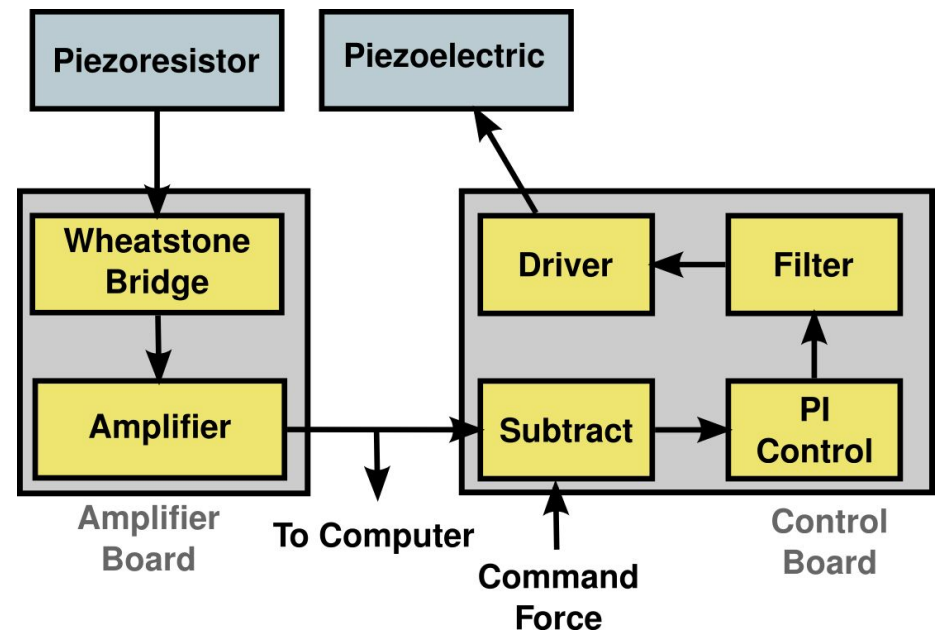
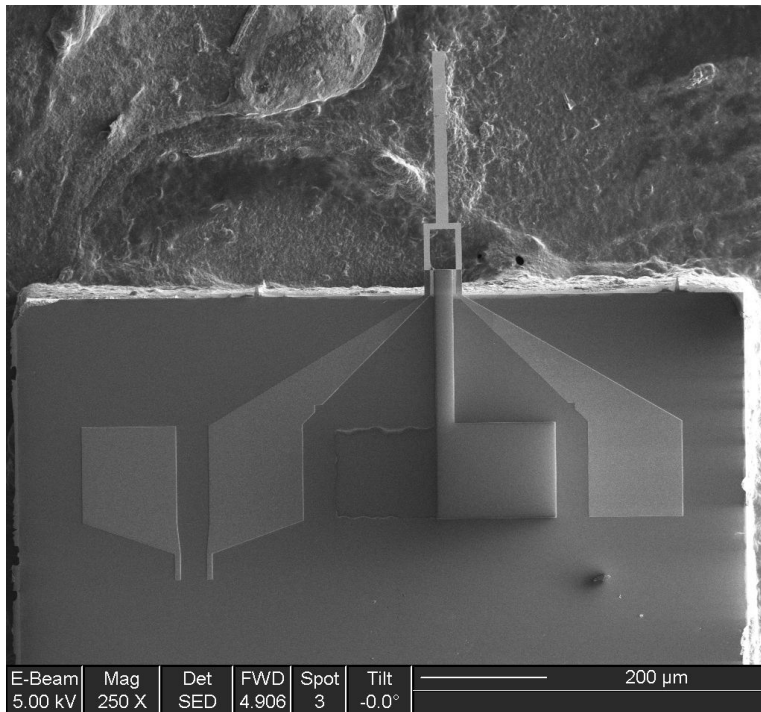
# Making a Better Force Probe

- Tools to study the molecular basis of touch and hearing
- MEMS probe vs. conventional probe
- Specs: pN force resolution, microsecond time resolution, closed loop force feedback, operation in salt water



# The Device

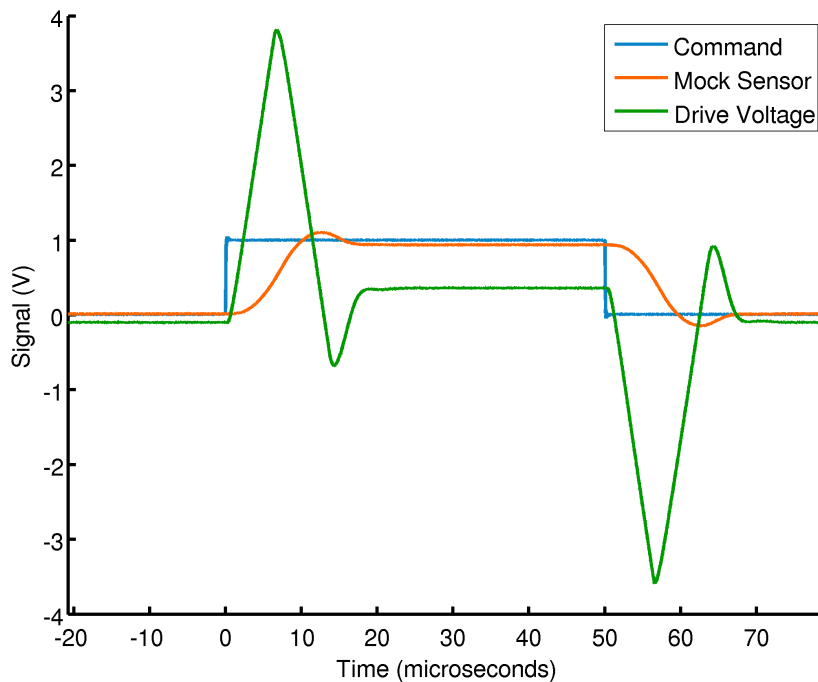
- Combine **piezoresistive** force sensing with **piezoelectric** actuation on a single very small cantilever beam
- Issues: design optimization, materials, feedback



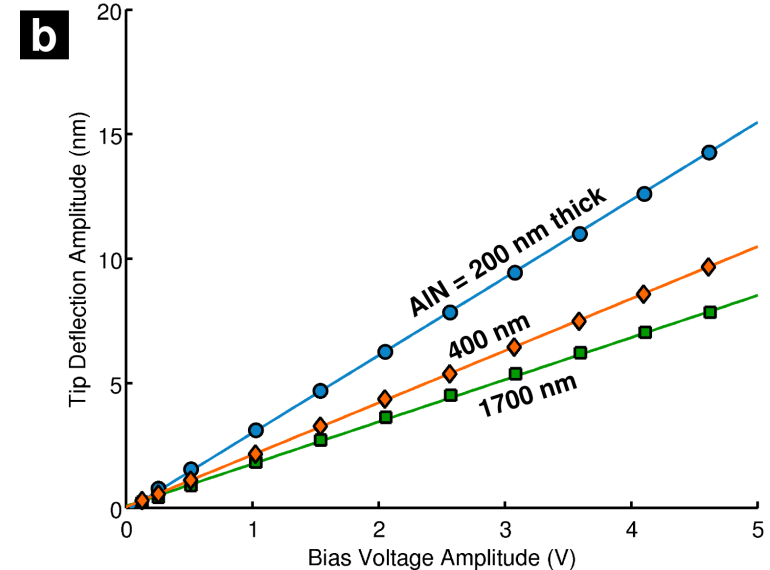
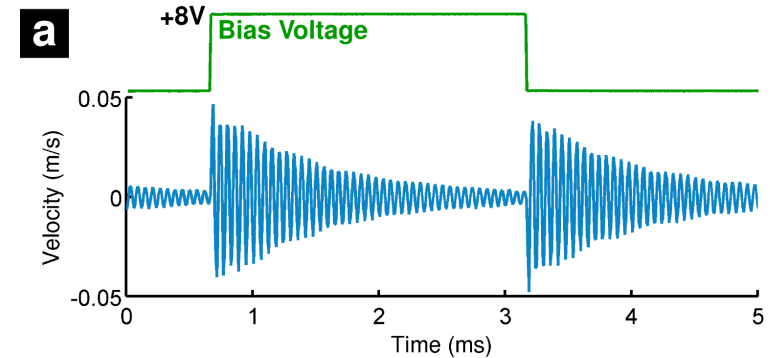
# Where Things Stand

| Design # | $f_0$ (kHz) | $f_{\max}$ (kHz) | R (k $\Omega$ ) | $F_{\min}$ Theory (pN) | $F_{\min}$ Exp. (pN) |
|----------|-------------|------------------|-----------------|------------------------|----------------------|
| 1        | 22          | 5                | 4.2             | 7.8                    | 5.2                  |
| 2        | 66.4        | 10               | 2.5             | 17.1                   | 51.7                 |
| 3        | 187.3       | 50               | 8.4             | 28.8                   | 298                  |
| 4        | 419.5       | 100              | 3.5             | 35.9                   | 678                  |

The piezoresistor works



The feedback works

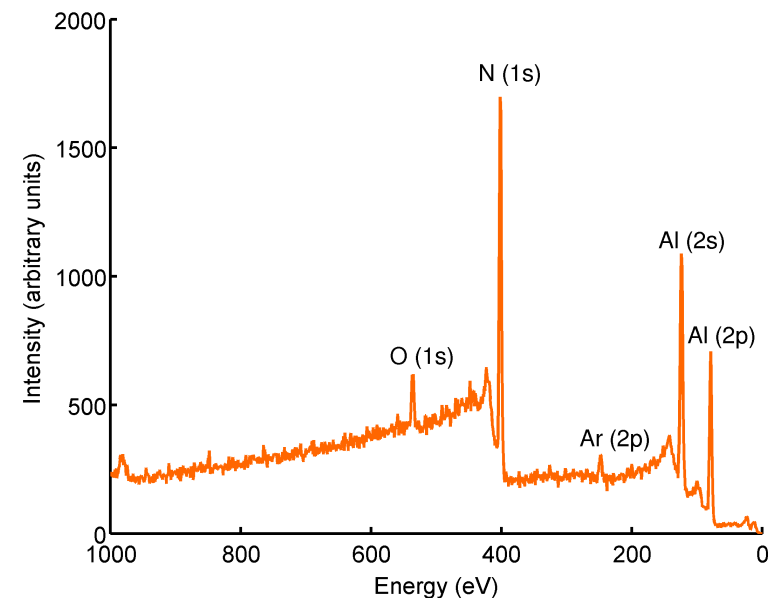
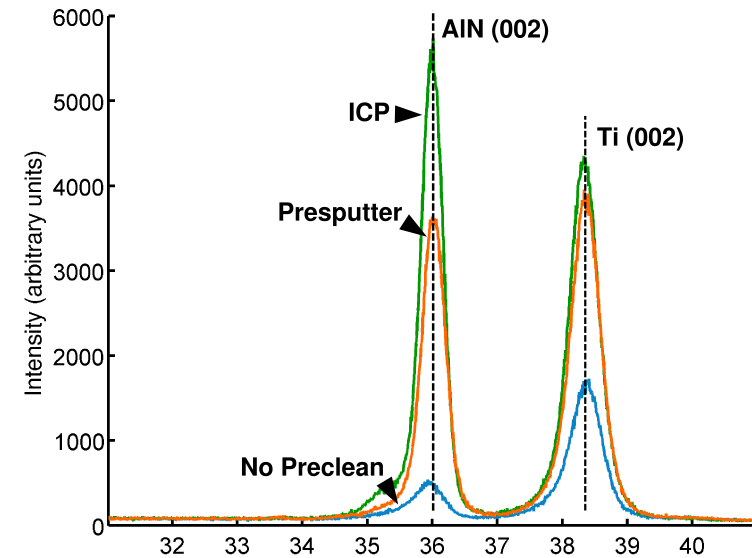


The piezoelectric works

**Next steps: test entire system, bio experiments, graduate**

# Tools of the Trade

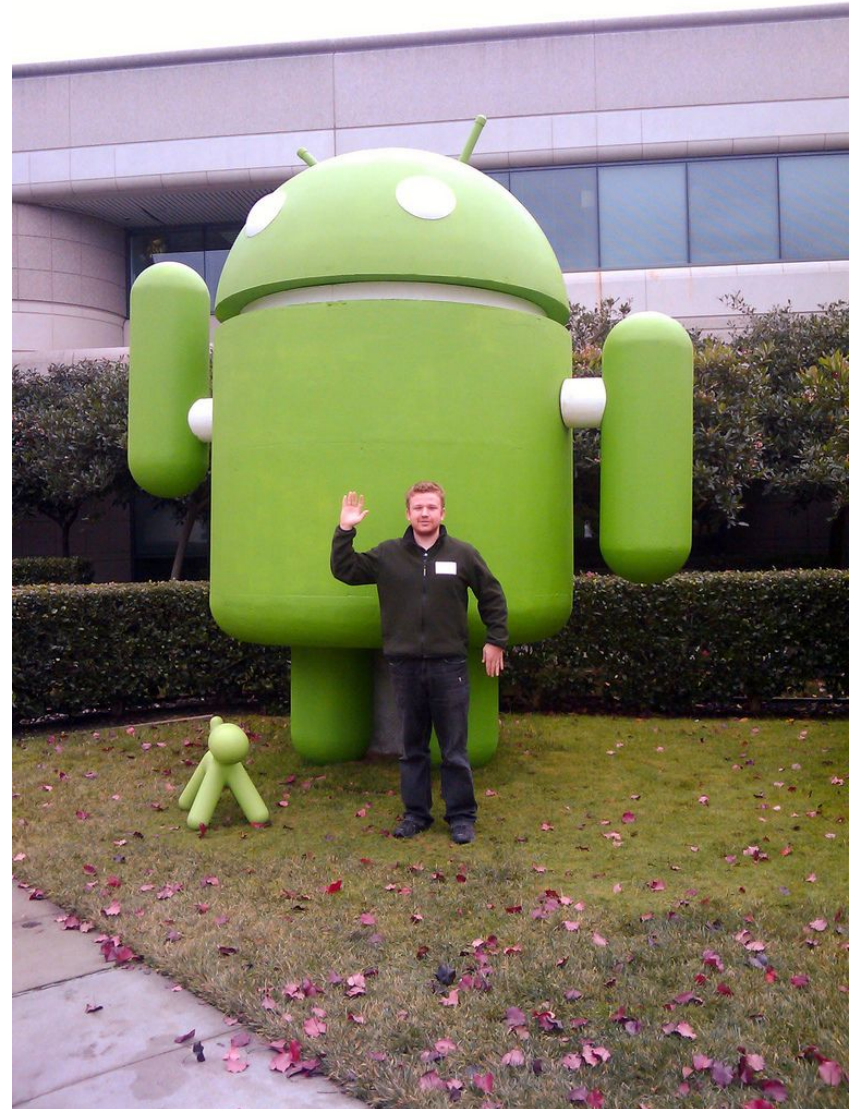
- Microfabrication
- X-ray diffraction
- Atomic force microscopy
- Auger electron spectroscopy
- Experiments of all kinds
- Printed circuit boards
- Doesn't get boring





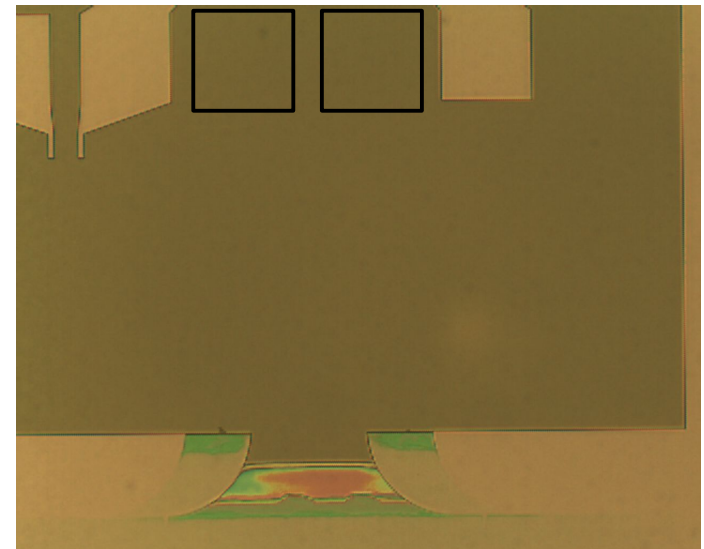
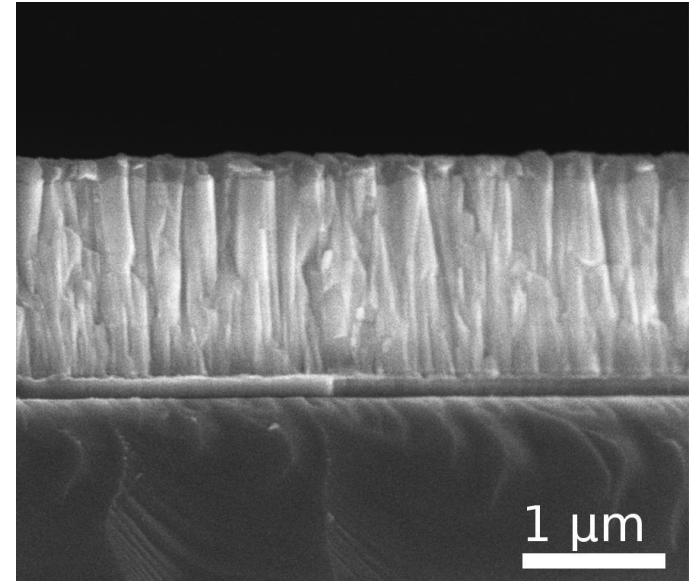
# Finding a Project is Iterative

- Worked on a different aspect of the same project when I first got here
- Research meltdowns aren't fun but happen
- Summer internship @ Google
- Switched project focus from bio to engineering



# The Importance of Being Scrappy

- I didn't get into Stanford, twice!
  - There's always another department...
- First year funding woes
  - Talk with a prof early and often
  - Fellowship applications are an art
- Getting your research to work
  - A thin line between your device working and not
  - Always have “duct tape” handy
  - Examples: piezoelectrics, fab





# Travel Opportunities Abound

- Did research at ETH Zurich for 3 months in 2008
- Funded by extension to NSF CAREER award
- Led to lots of fun and a conference paper





# Misc. Stuff

- Quals: Practice at the board!
- Classes: 0 or 2 per quarter works well
- Funding: Find a professor, go to group meetings, be persistent, find a class to CA, fellowship applications
- SNF: Plan on things not working and have backups for your backups

Thanks!

