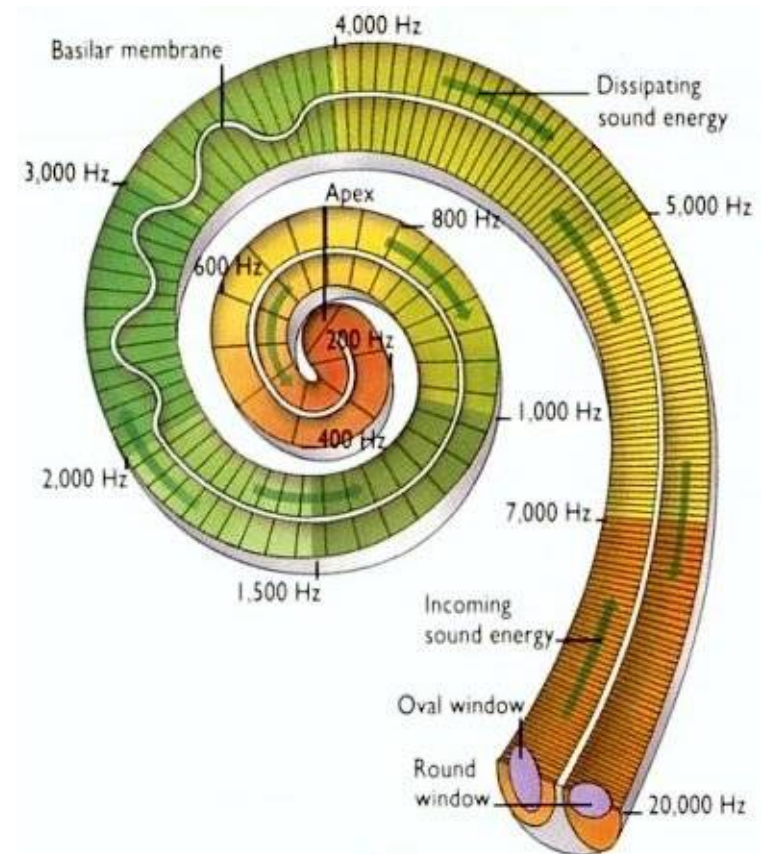
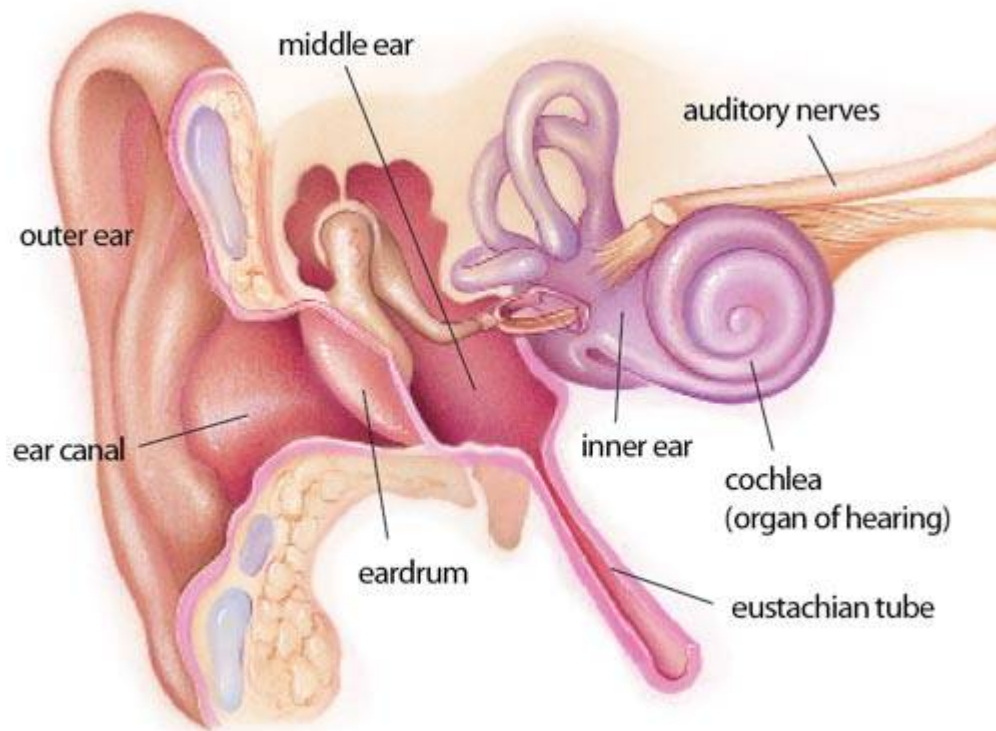


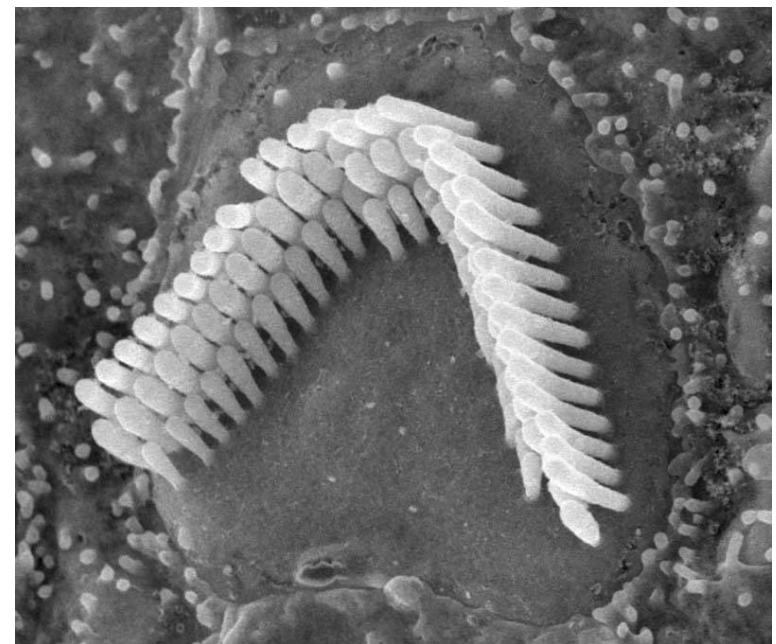
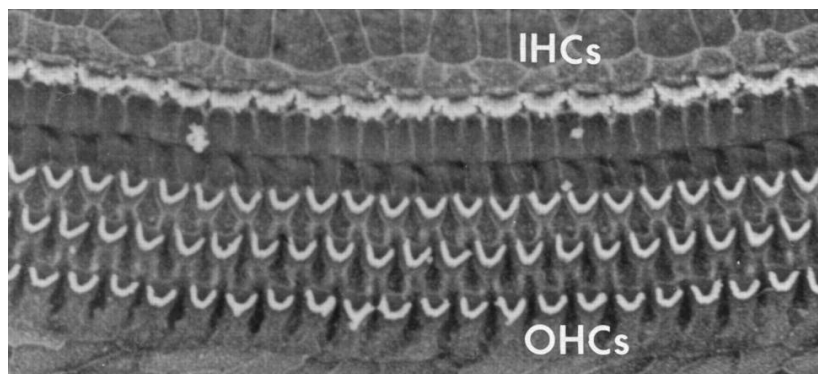
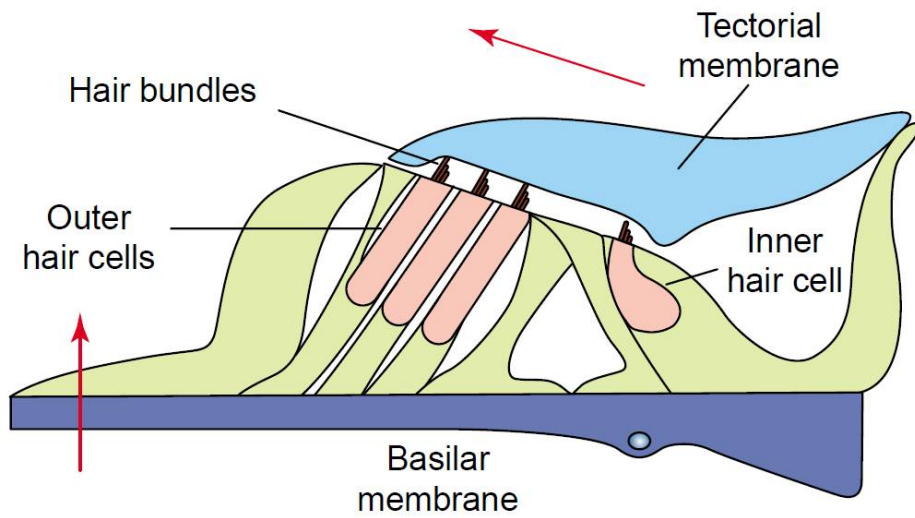
# Worm Club Research Update

Joey Doll  
12/5/2011

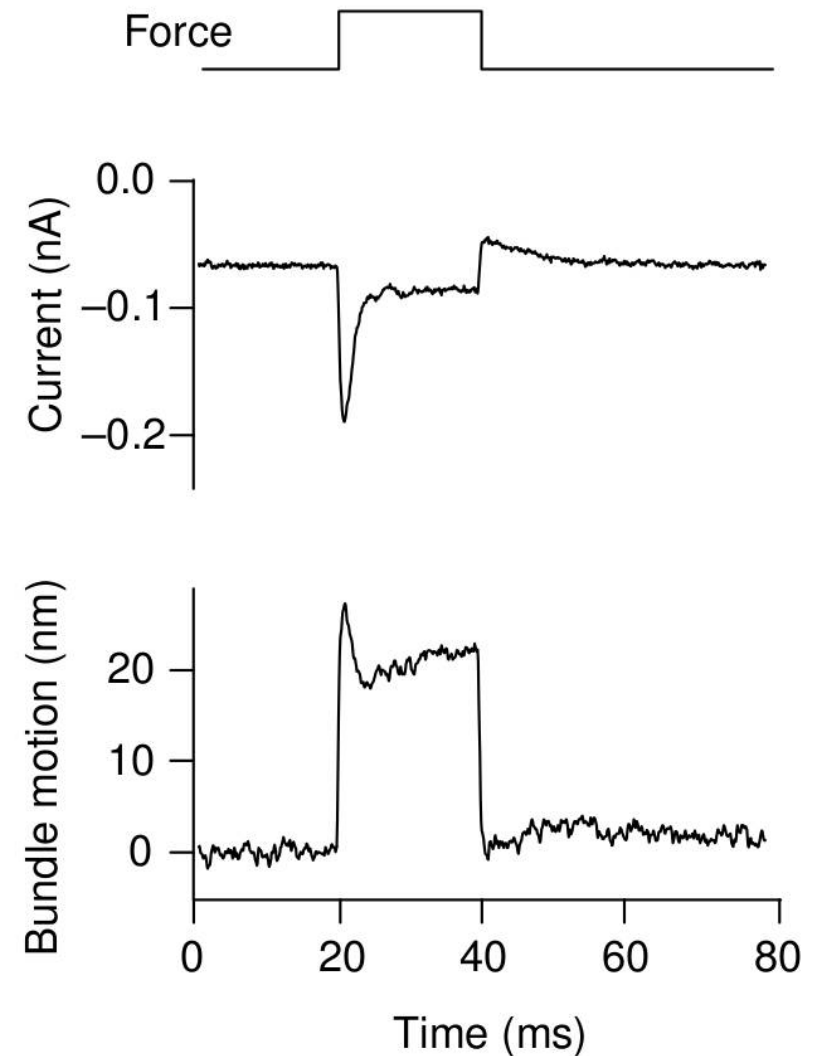
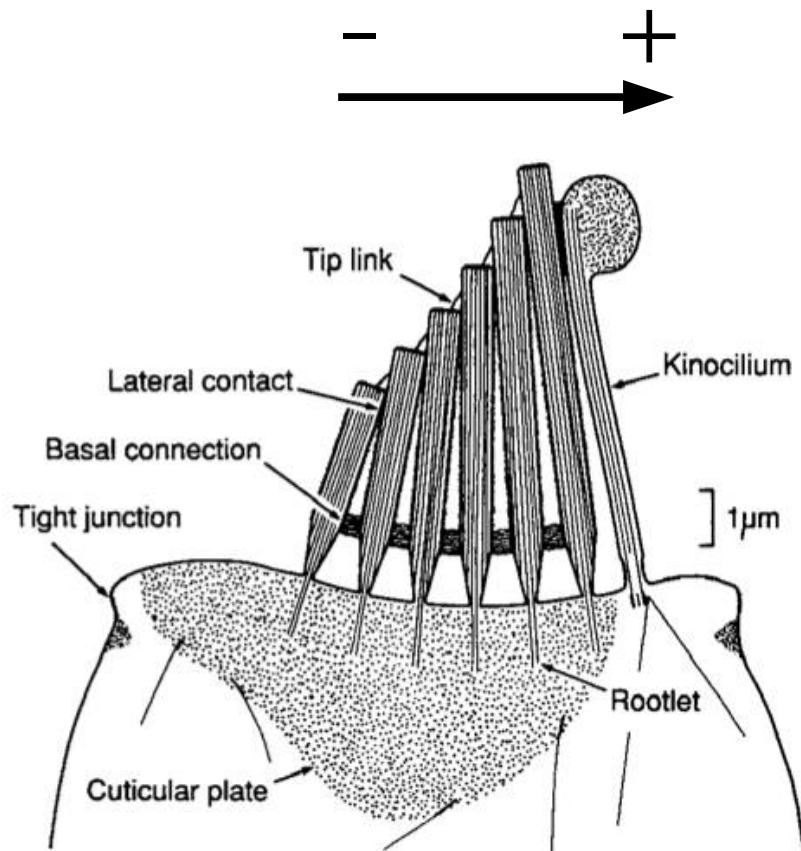
# Outline

- Why poke hair cells?
- Device design and performance
- Hair cell stimulus results





# Hair Cells as Mechanical Transducers

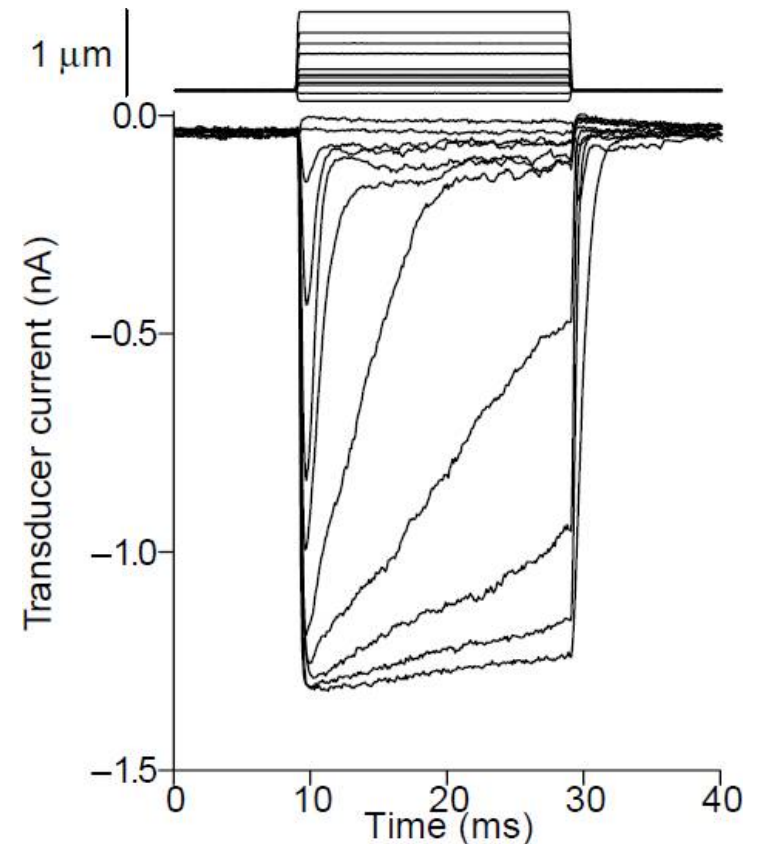
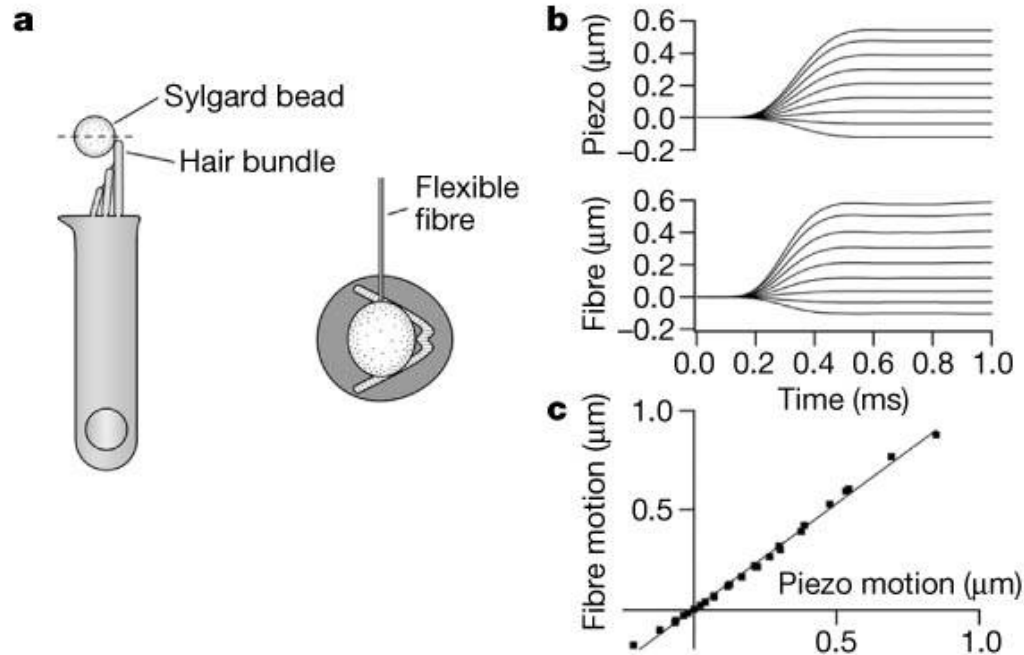




# Current Experimental Methods

## Experiments

- 1) Mechanics
- 2) Kinetics
- 3) Motility



Project image onto photodiode

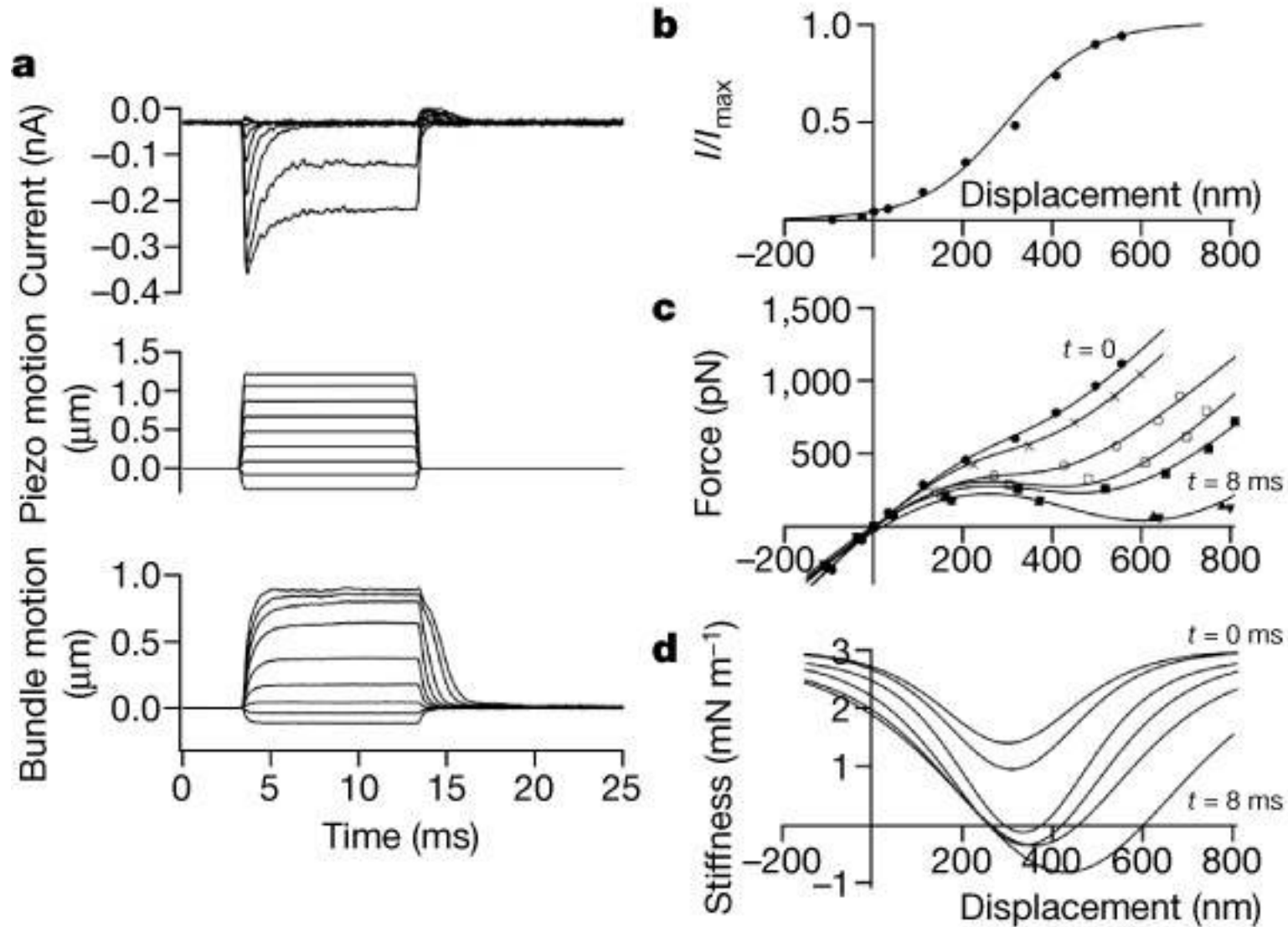
Mechanics: 1 kHz, 1 mN/m

Kinetics: 5-10 kHz,  $>10$  mN/m

## Problem

Macroscale force probes are too slow for mammalian hair cells

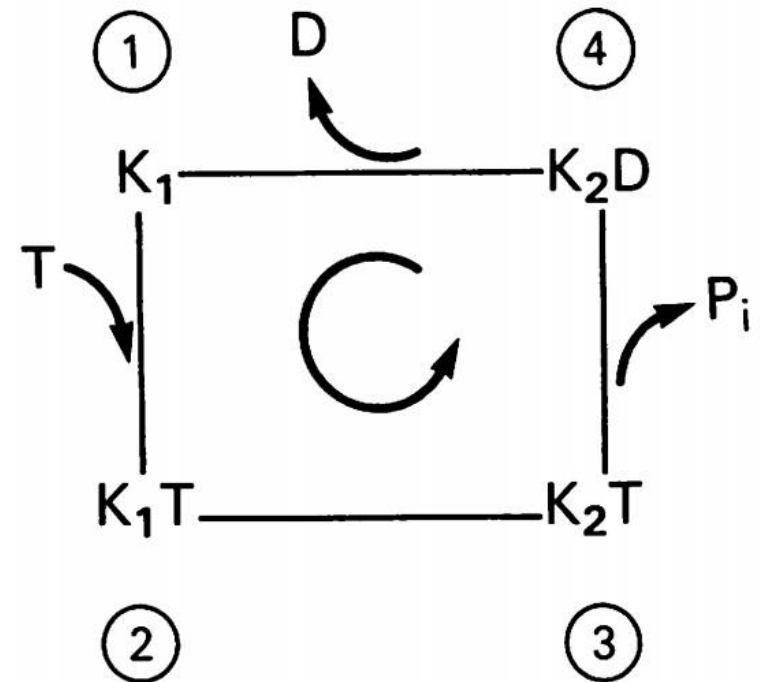
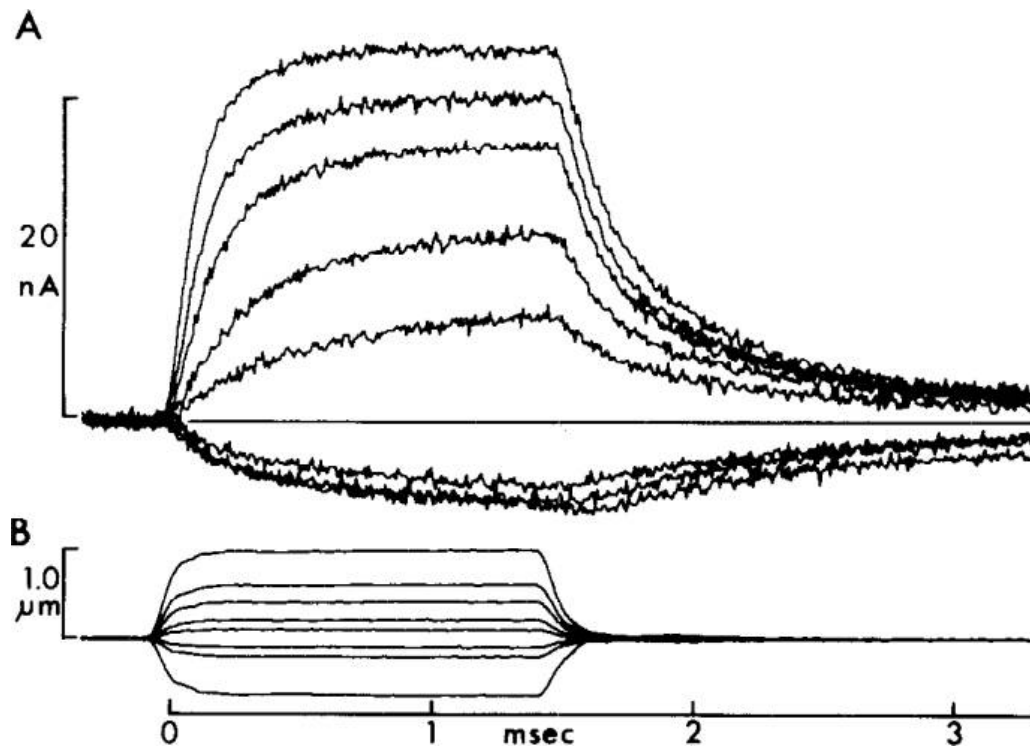
# Bundle Mechanics



# Channel Kinetics

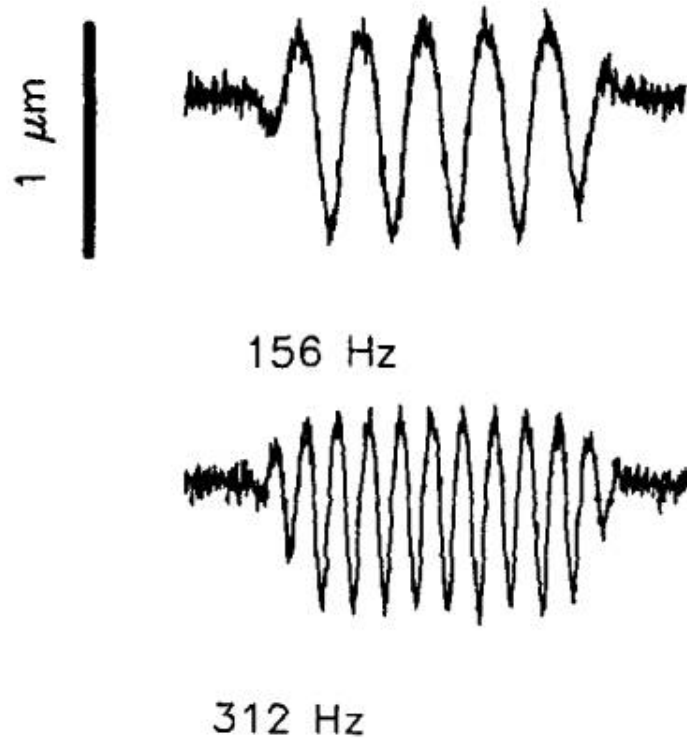
Amphibian kinetics: 10 kHz

Mammalian kinetics: ???





# Outer Hair Cell Motility



OHCs as a source of positive feedback  
(the search for the cochlear amplifier)



Source: Joe Santos-Sacchi

Motile force not measured to date  
(length inferred from capacitance)

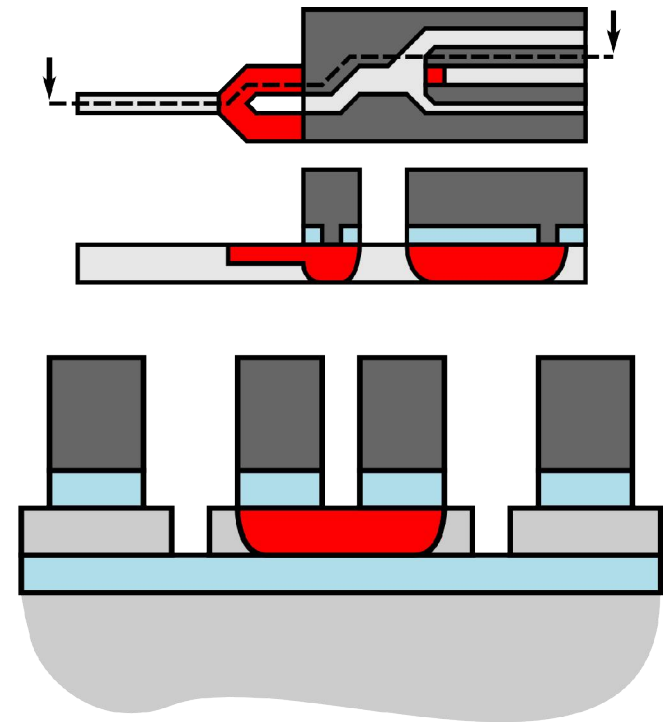
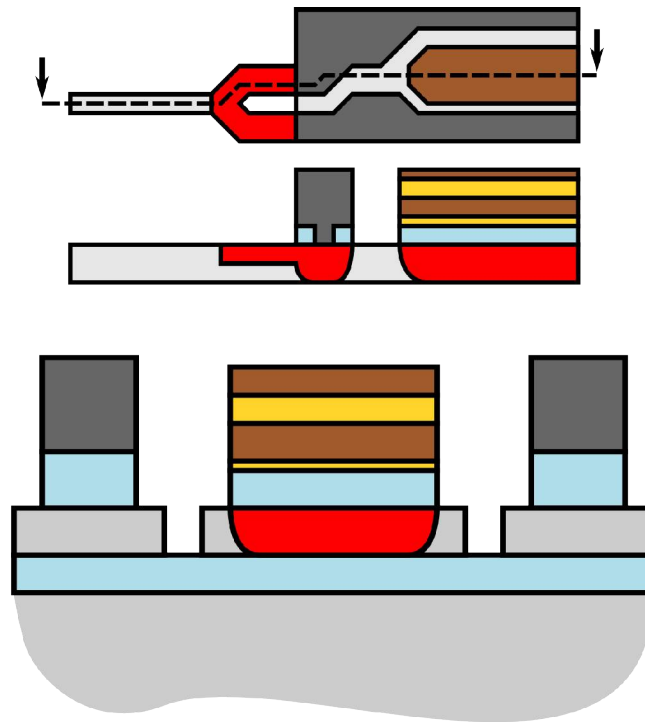
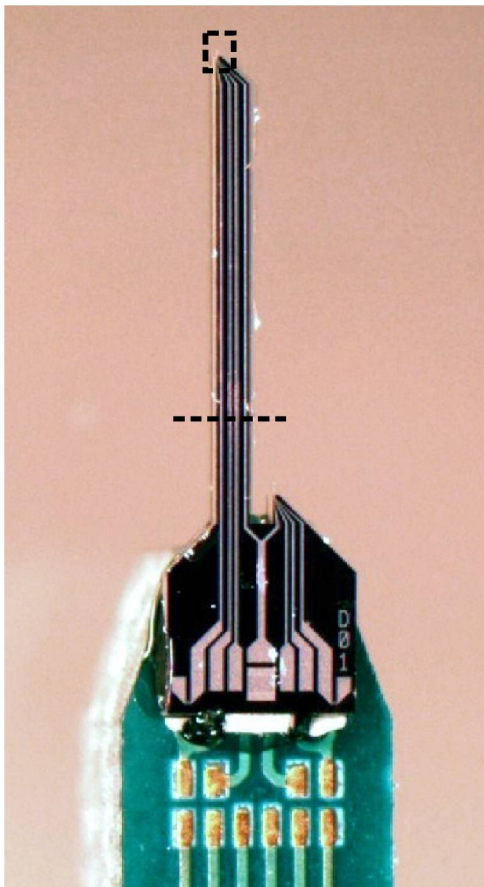
# Design Targets

	Design #	$l_c$ ( $\mu\text{m}$ )	$l_{pr}$ ( $\mu\text{m}$ )	$k$ (mN/m)	$f_d$ (kHz)	$t_r$ ( $\mu\text{sec}$ )	$R_{pr}$ (k $\Omega$ )	MDD (nm)	MDF (pN)
Kinetics Mechanics	1	142	12.6	0.3	3.3	286	4.1	11	3.3
	2	96	9.5	1.0	9.7	60	3.2	6.3	6.2
	3	75	7.7	2.1	19	23	2.7	4.6	9.6
	4	61	6.6	3.9	32	11	2.4	3.6	14
	5	46	5.2	9.0	64	4.6	2.0	2.7	24
	6	35	4.1	20.4	124	2.0	1.6	2.1	42
	7	29	3.6	35.8	190	1.2	1.5	1.7	61

# Device Design

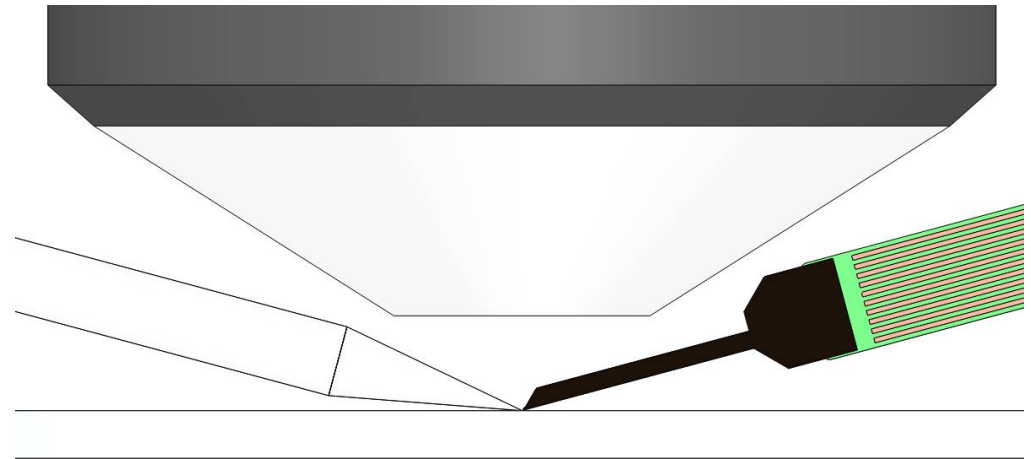
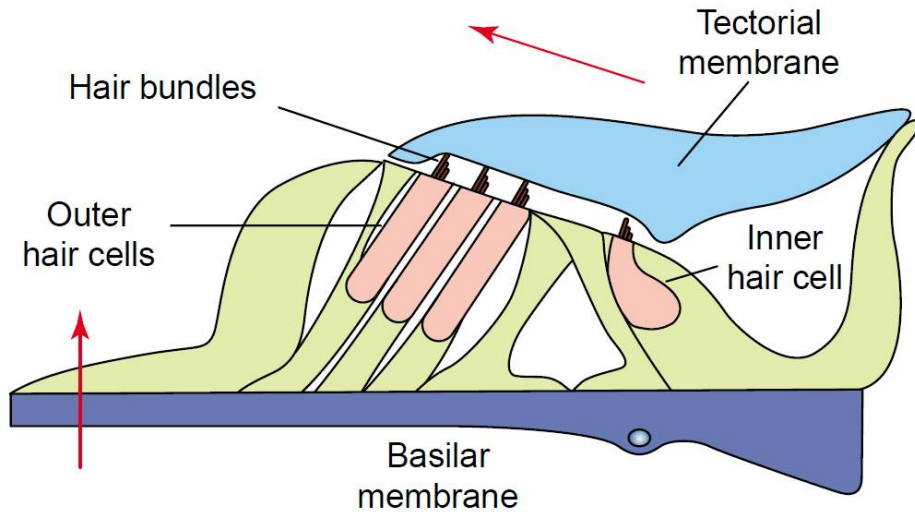
Piezoelectric actuation (PRPE)

Thermal actuation (PRT)

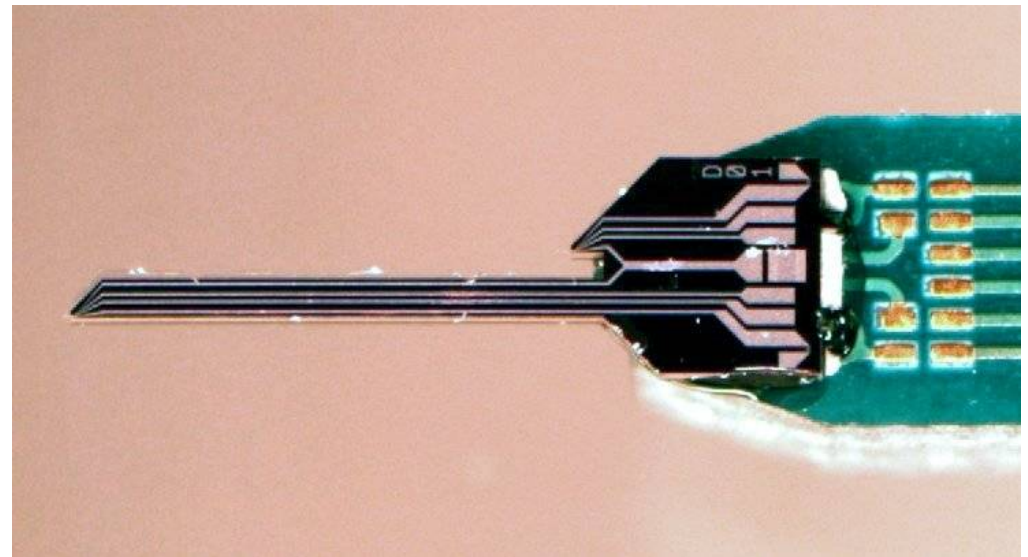


- |            |     |
|------------|-----|
| Undoped Si | Al  |
| Doped Si   | Mo  |
| Oxide      | AlN |

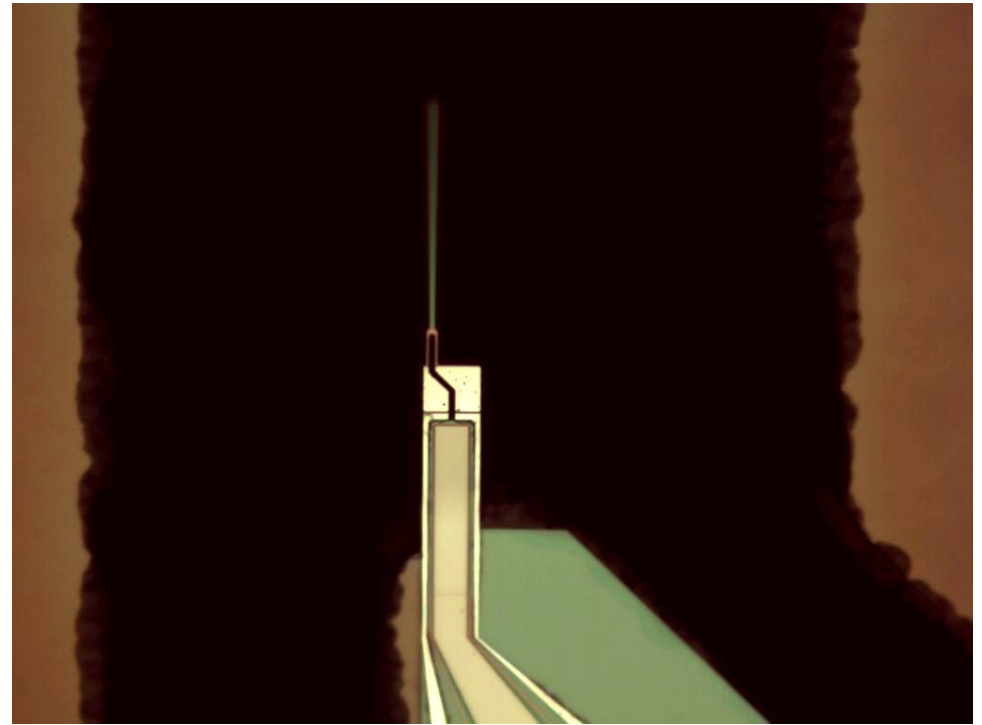
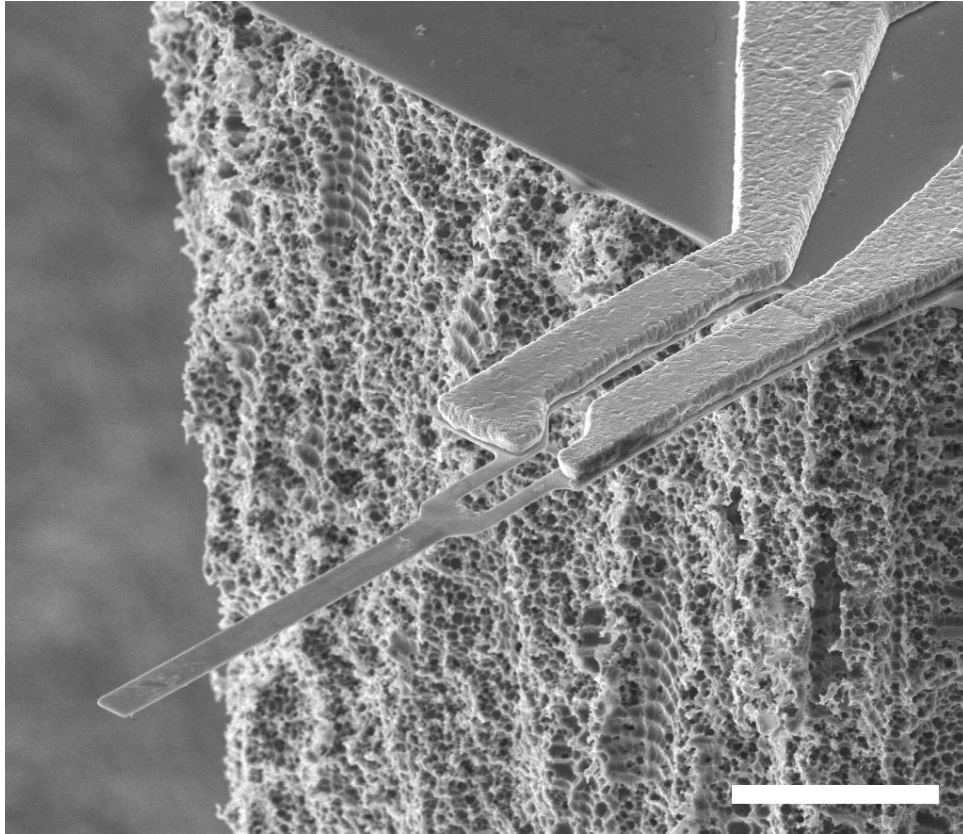
# Macroscale Probe Design



- Upright microscope
- 2mm working distance
- In-plane forces



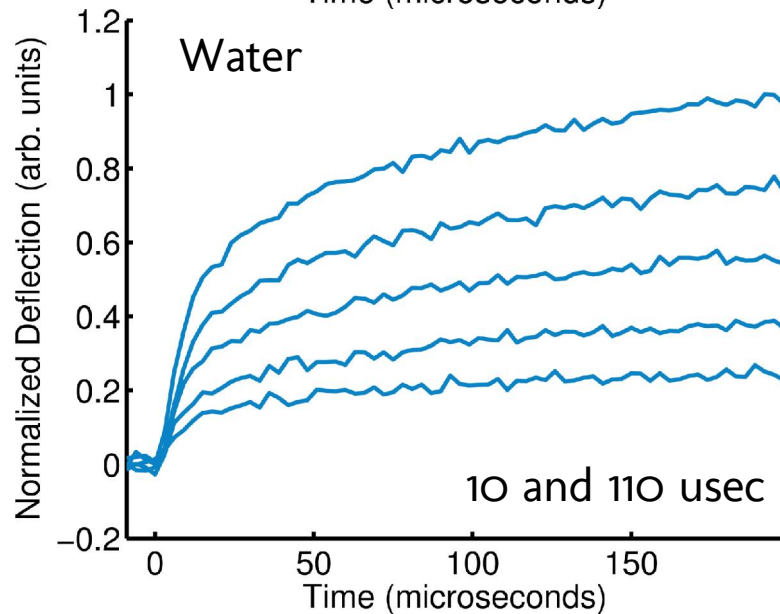
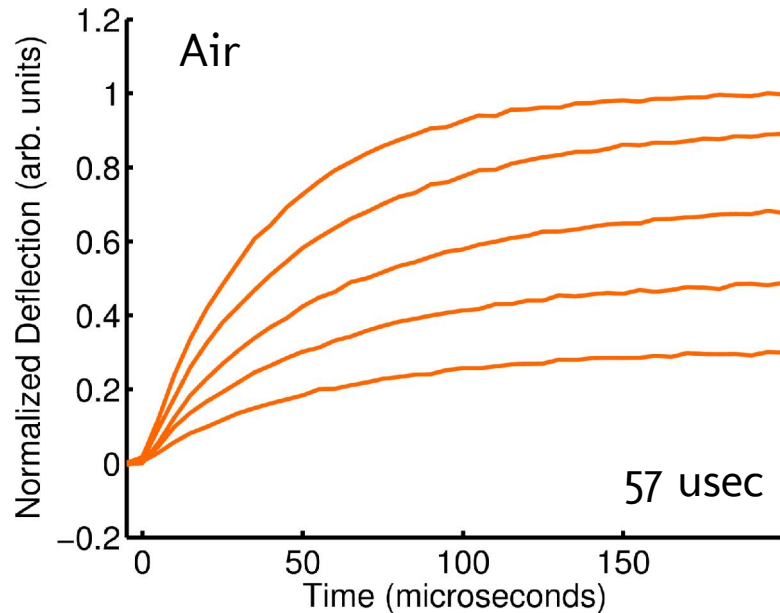
# Finished Devices



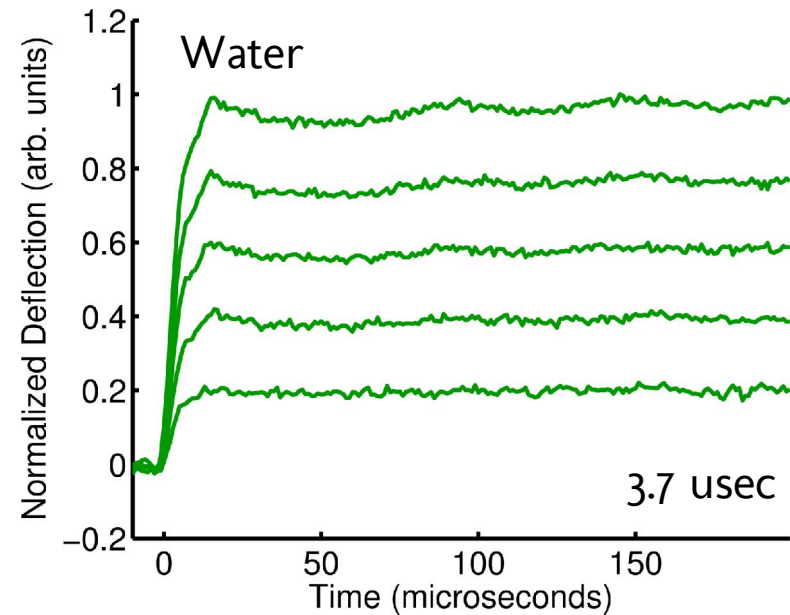


# Actuator Step Response

Thermal Actuator

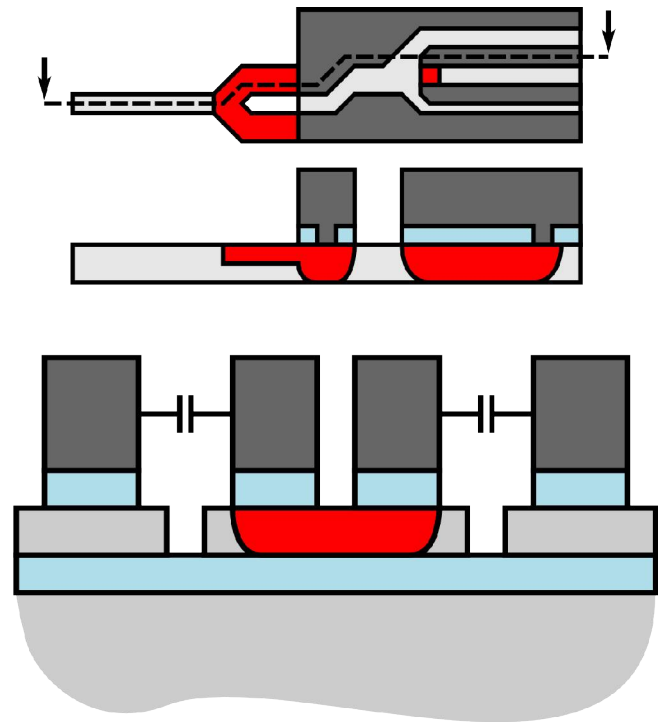
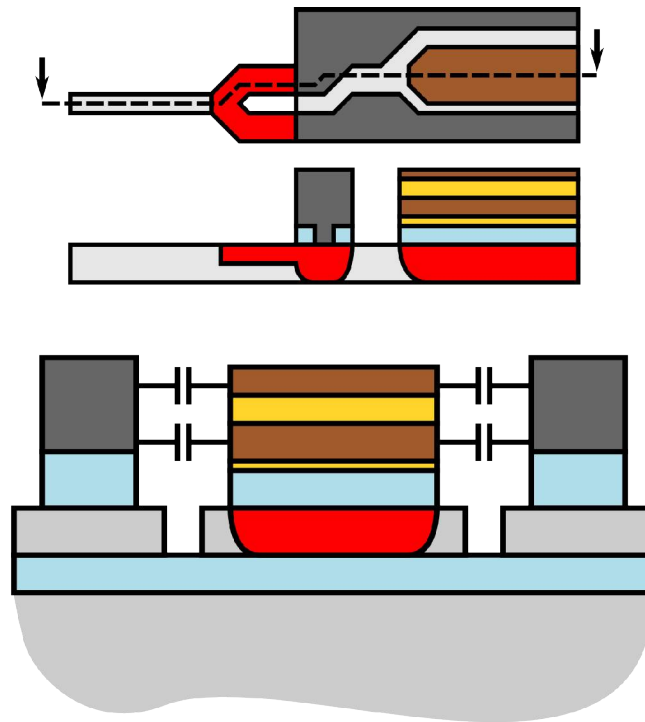
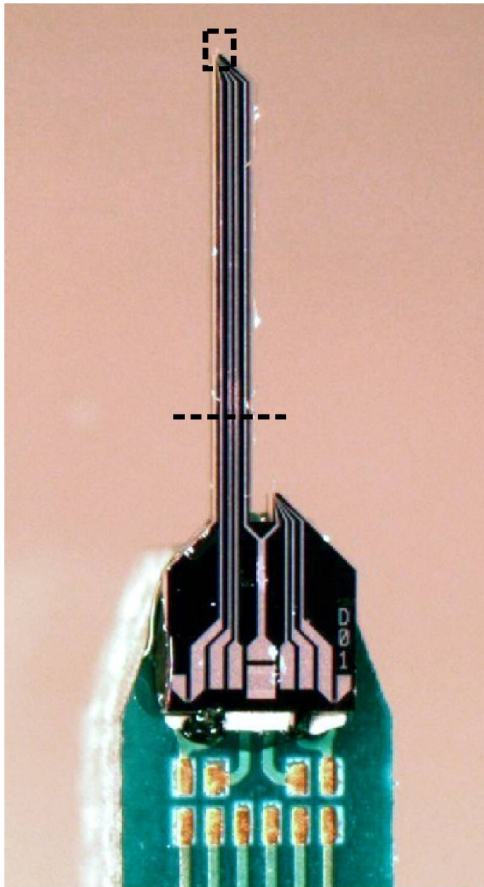








Piezoelectric Actuator





# Actuator-Sensor Crosstalk

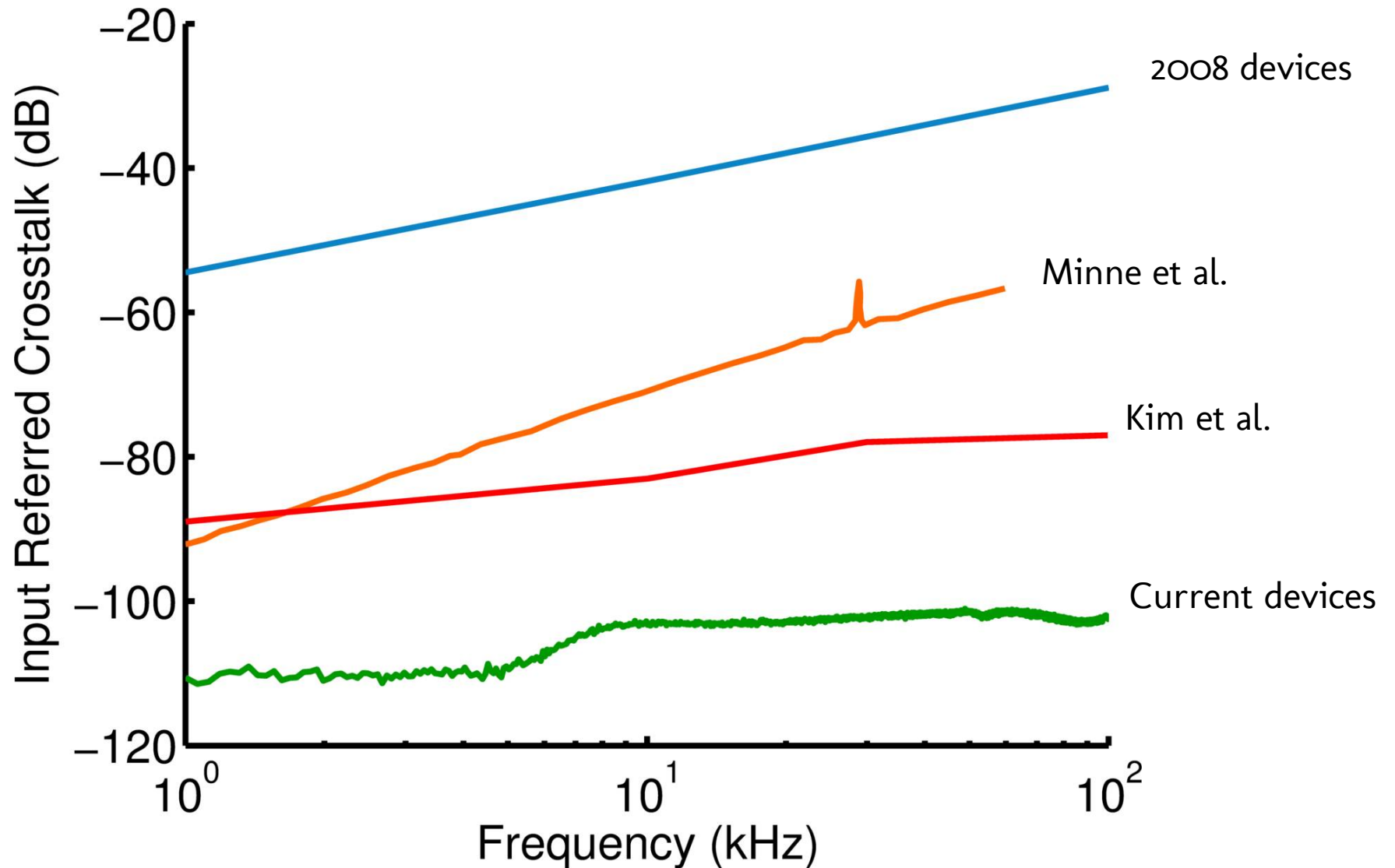


- |  |  |
|--|--|
|  Undoped Si |  Al  |
|  Doped Si   |  Mo  |
|  Oxide      |  AlN |

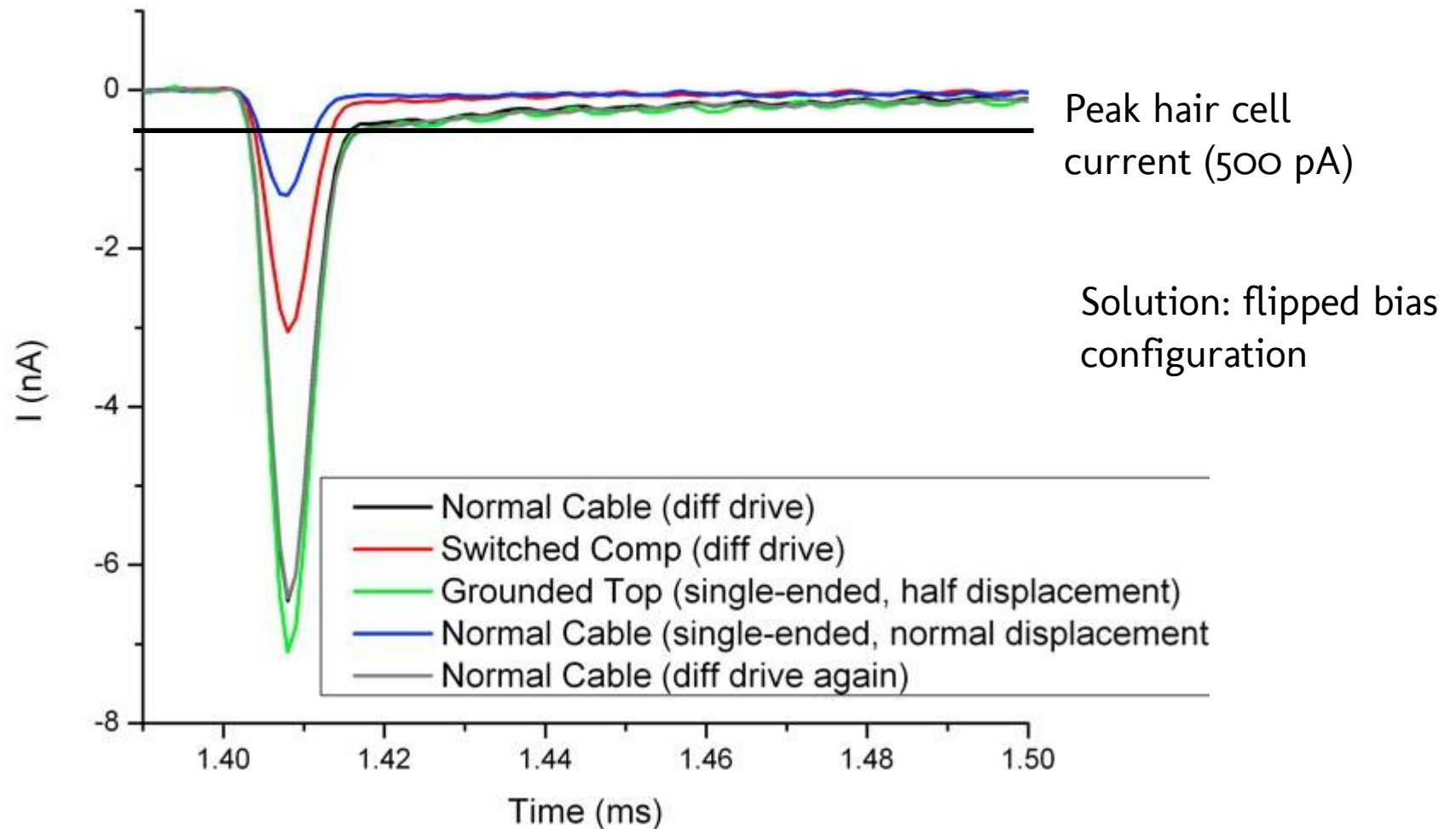
- Mechanisms
- 1) **Capacitive**
  - 2) Thermal

- Biasing
- 1) Single ended
  - 2) Differential

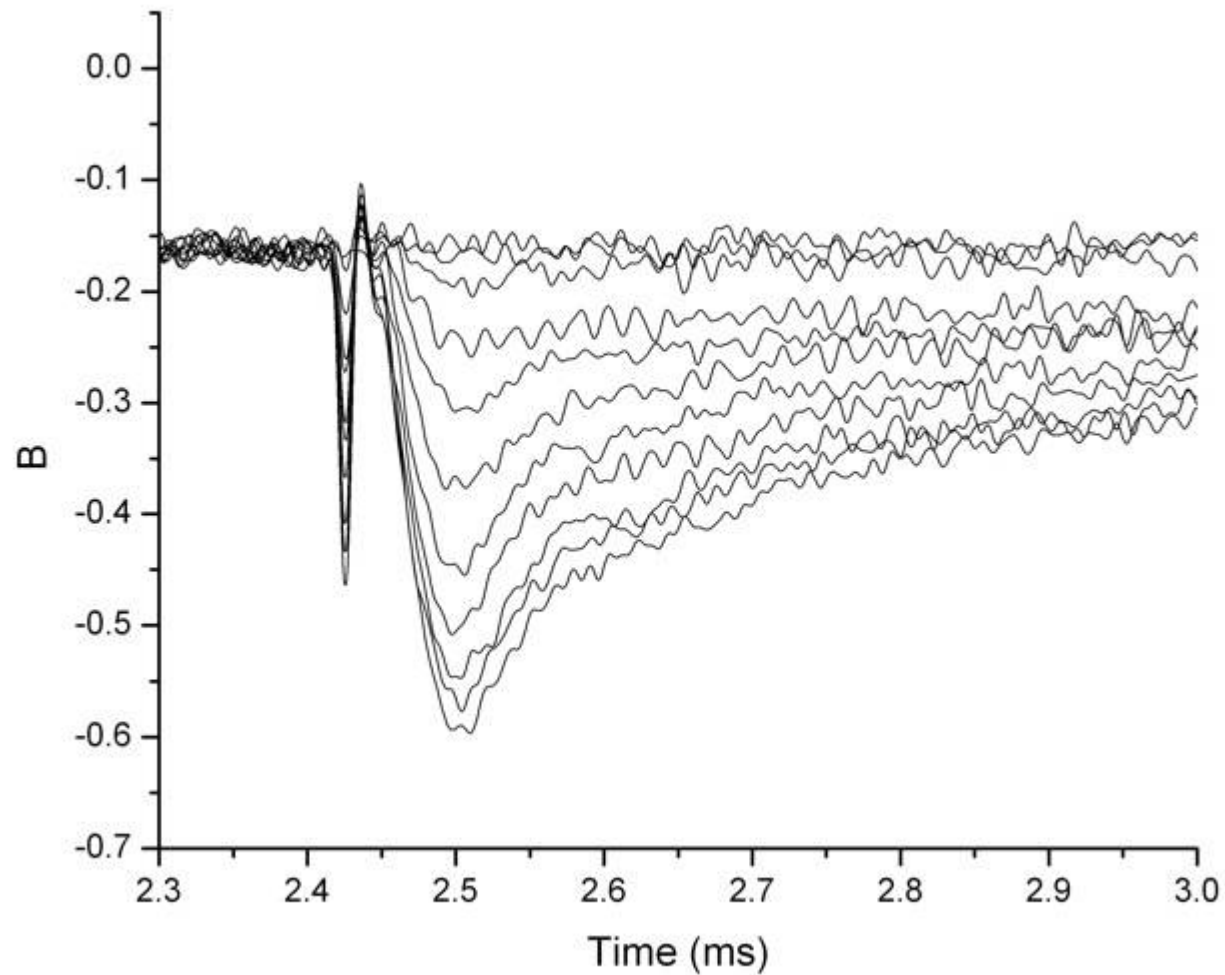
# Crosstalk Results



# Actuator-Patch Clamp Crosstalk



# First Hair Cell Results



# Ongoing Work

- Solve the soft probe problem
  - Preliminary O<sub>2</sub> plasma treatments done
- Prep more devices for experiments
- Wrap up characterization
  - Frequency response in liquid
  - Temperature
  - Finalize analysis and start writing up results