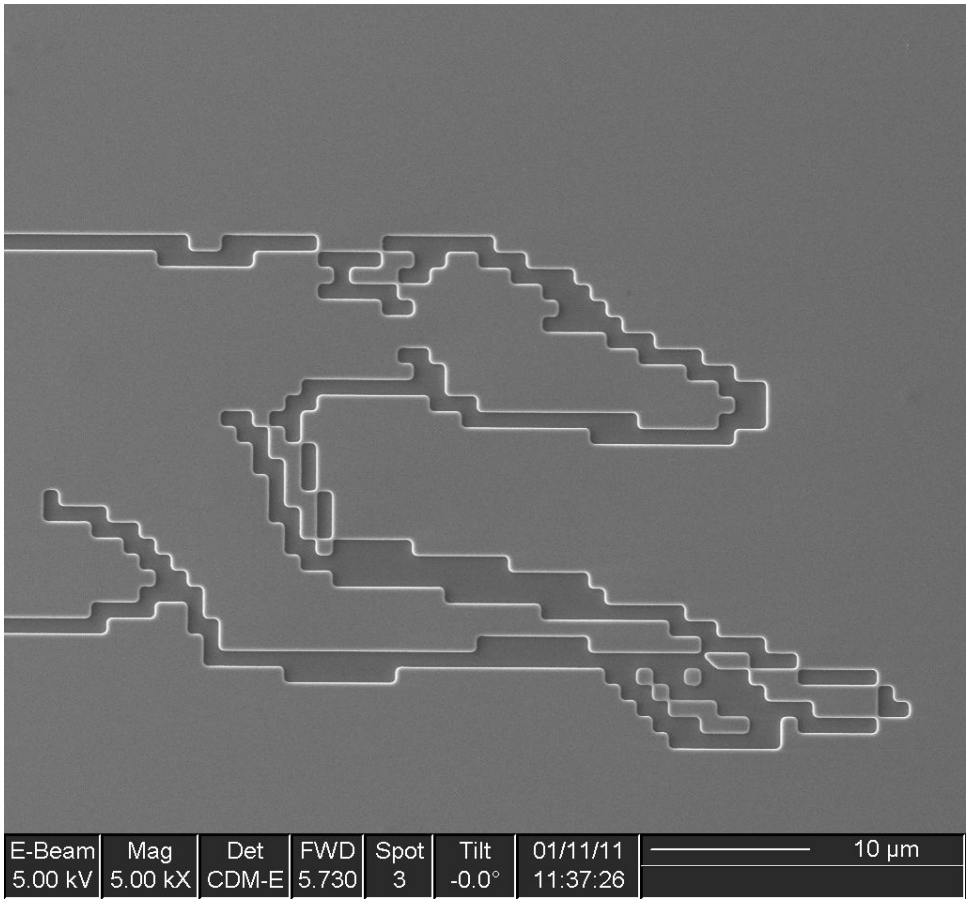
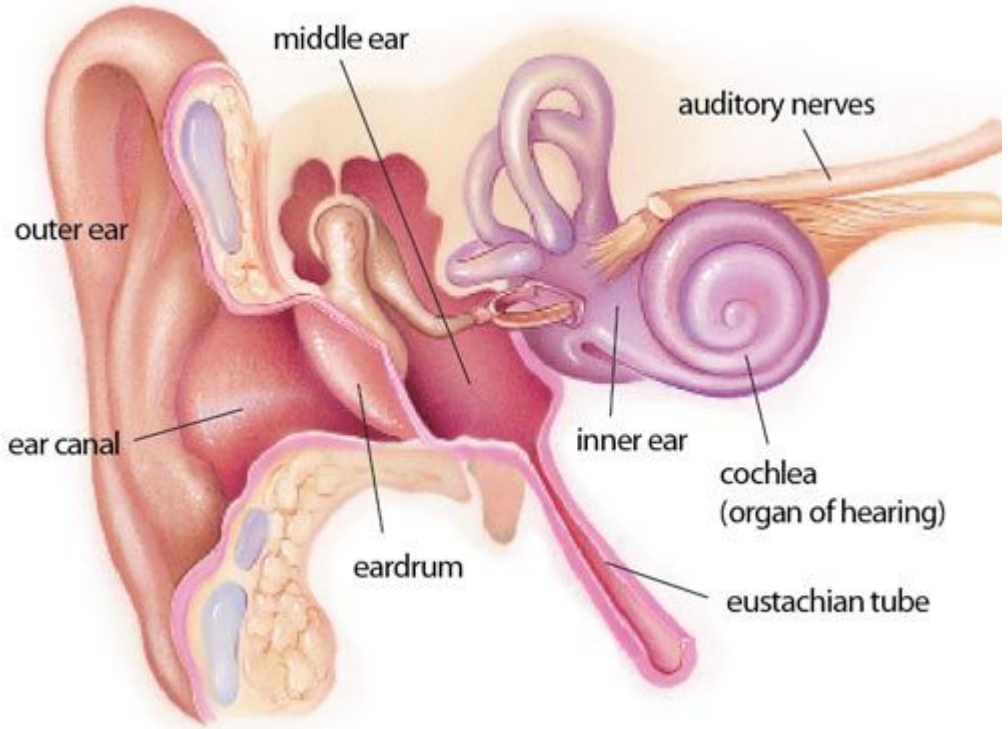
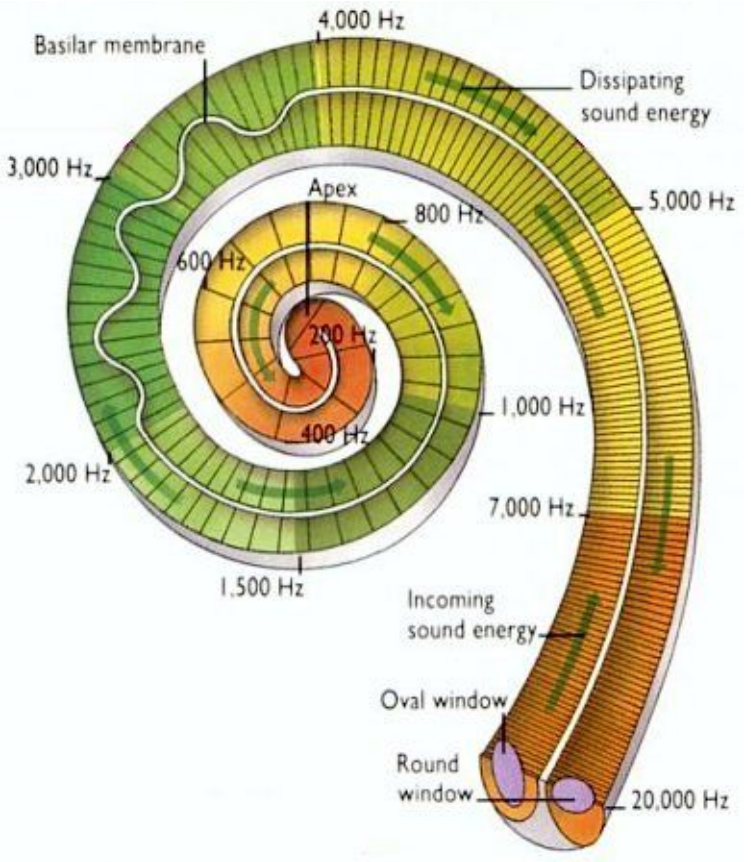


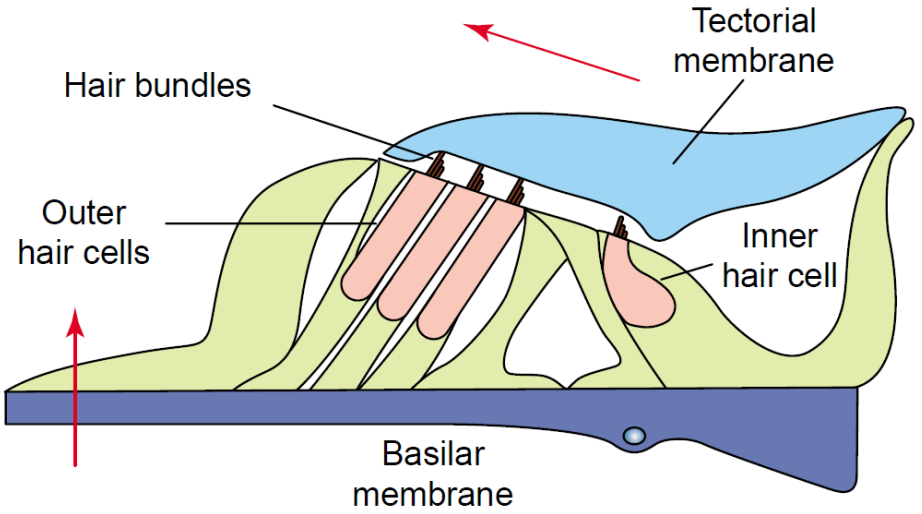
Green Light Meeting

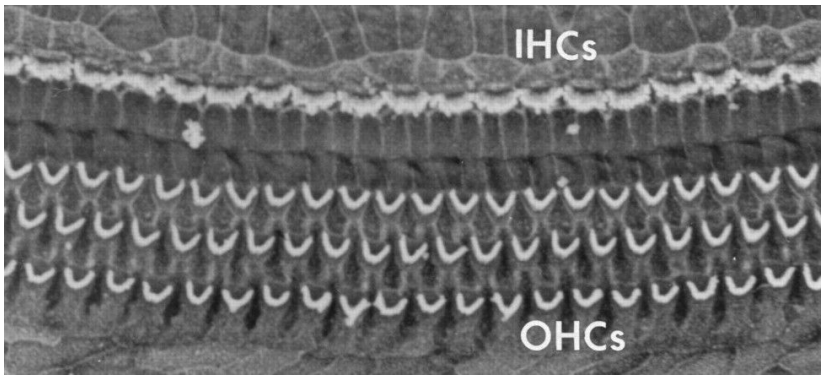
Joey Doll

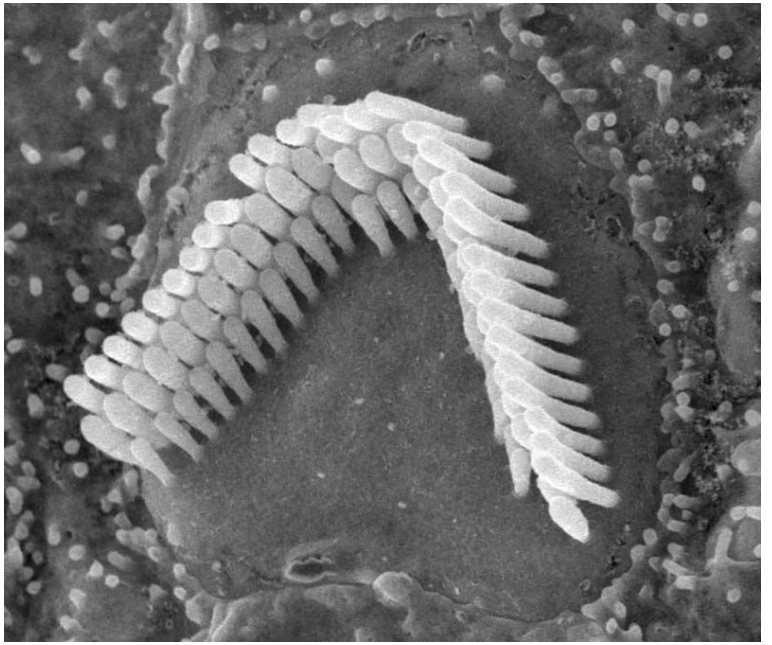
10/27/2011


middle ear
auditory nerves
outer ear
ear canal
inner ear
cochlea
(organ of hearing)
eardrum
eustachian tube

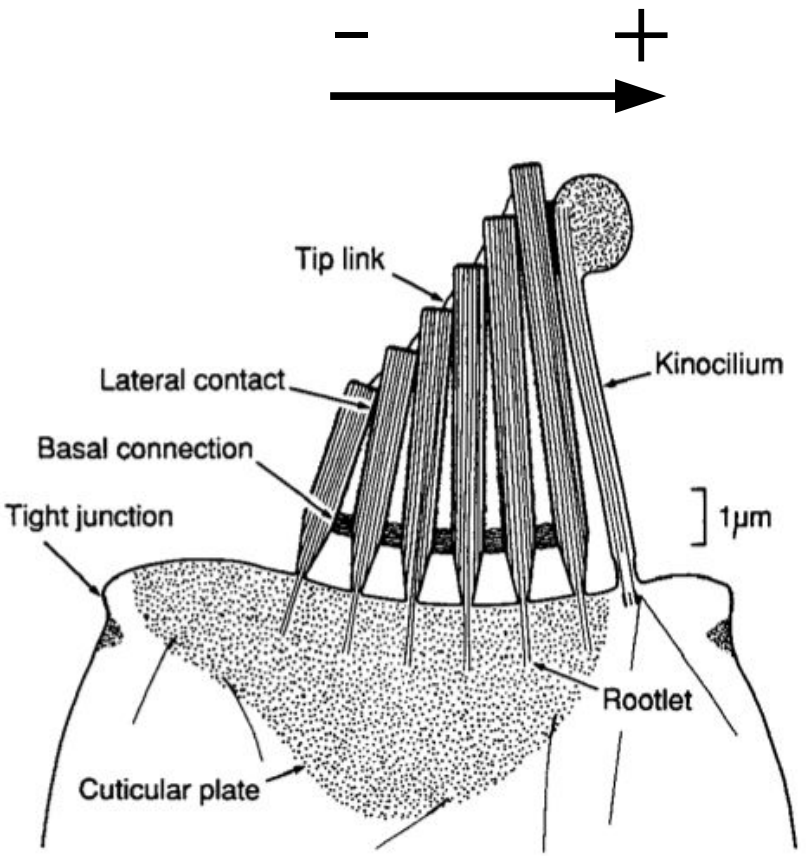

4,000 Hz
Basilar membrane
Dissipating
sound energy
3,000 Hz
5,000 Hz
Apex
800 Hz
600 Hz
200 Hz
400 Hz
1,000 Hz
2,000 Hz
7,000 Hz
1,500 Hz
Incoming
sound energy
Oval window
Round
window
20,000 Hz

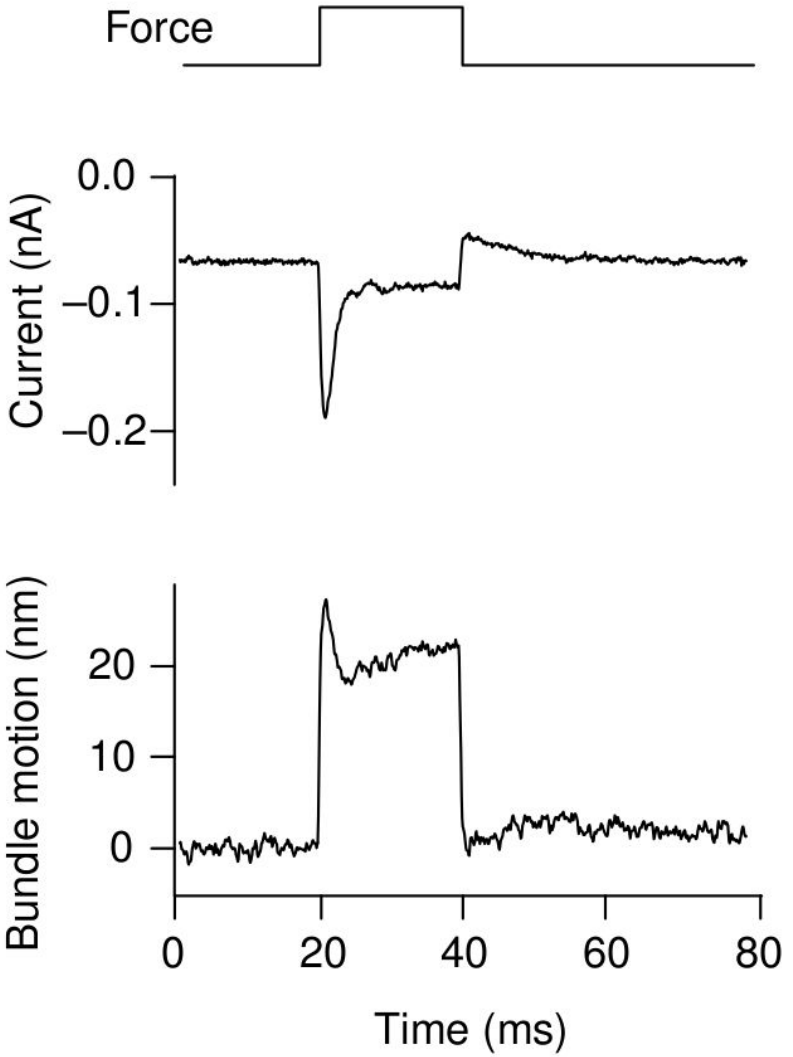

Tectorial membrane
Hair bundles
Outer hair cells
Inner hair cell
Basilar membrane


IHCs
OHCs

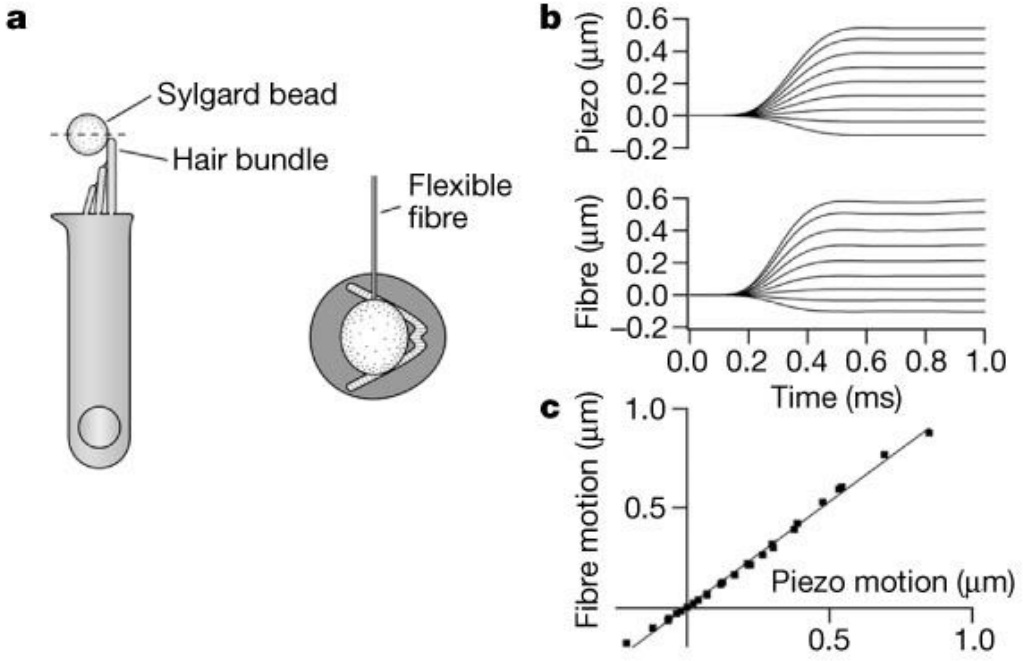


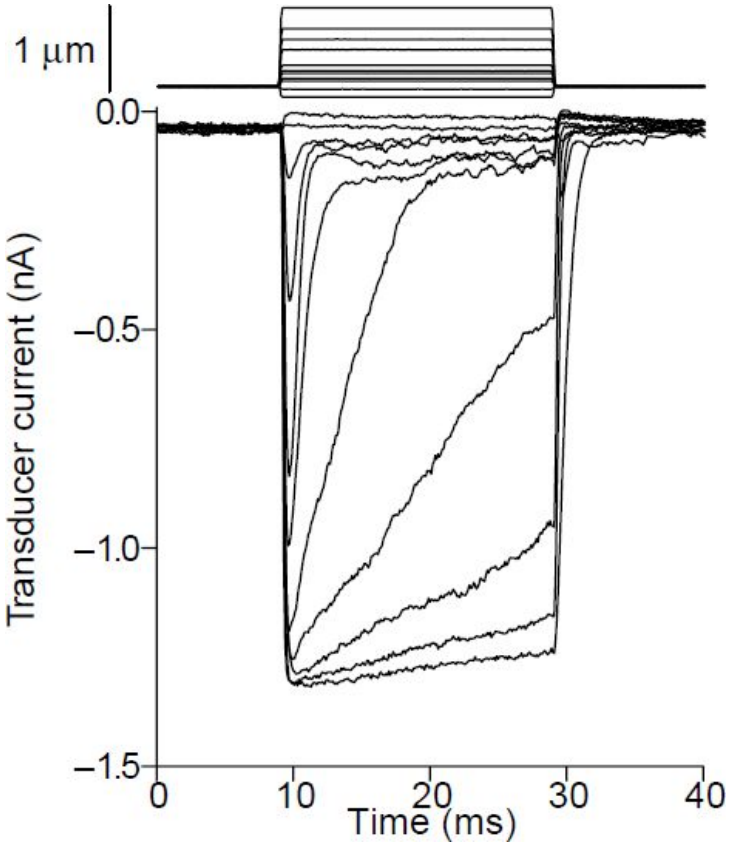
Hair Cells as Mechanical Transducers





Current Experimental Methods





Project image onto photodiode
Mechanics: 1 kHz, 1 mN/m
Kinetics: 5-10 kHz, >10 mN/m

<u>Problem</u>

Macroscale force probes are too slow for mammalian hair cells

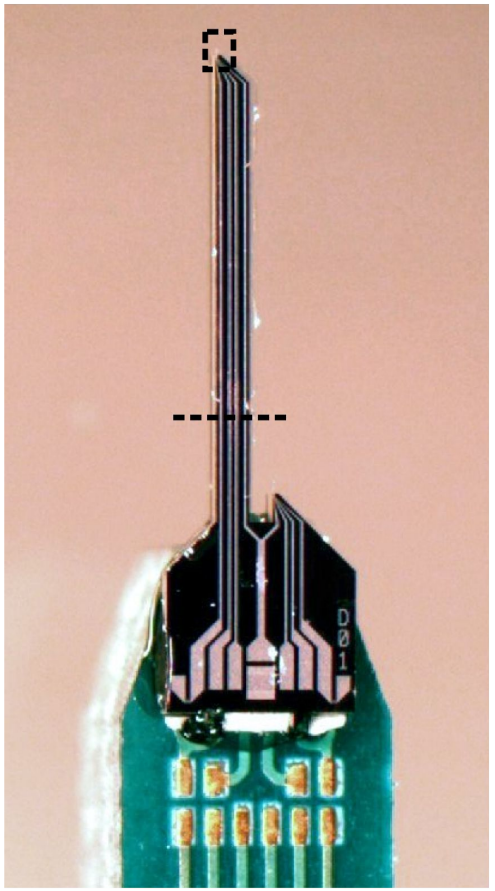
Design Targets

Design #	l_c (μm)	l_{pr} (μm)	k (mN/m)	f_d (kHz)	t_r (μsec)	R_{pr} (kΩ)	MDD (nm)	MDF (pN)
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

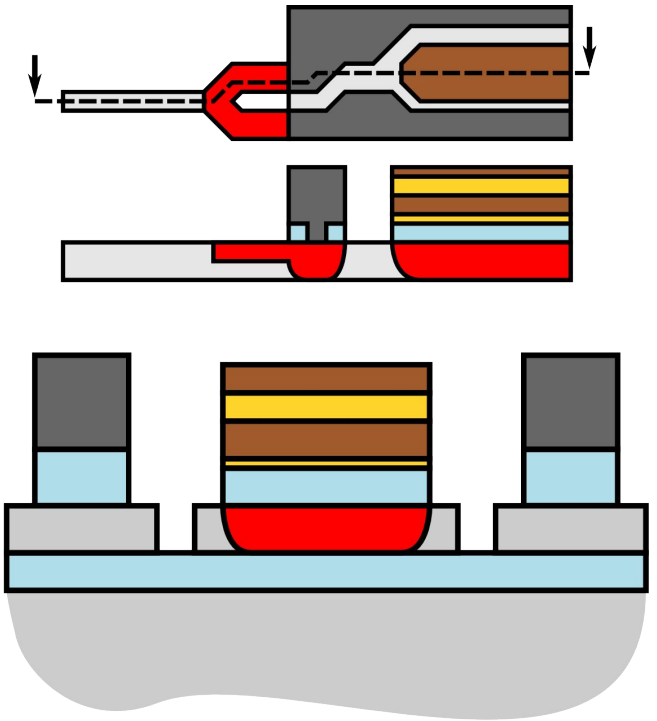
Mechanics

Kinetics

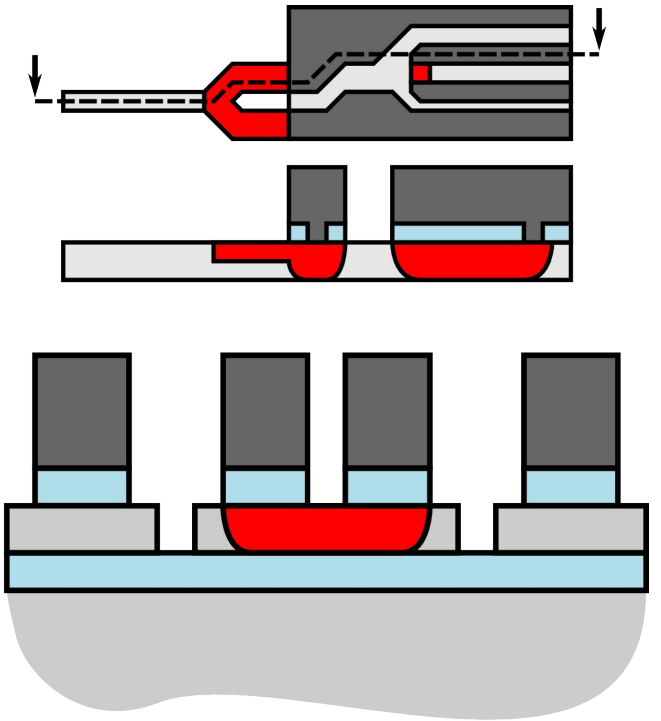
Device Design

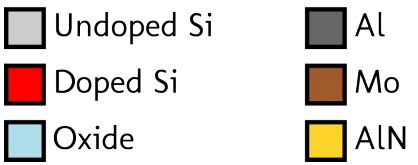


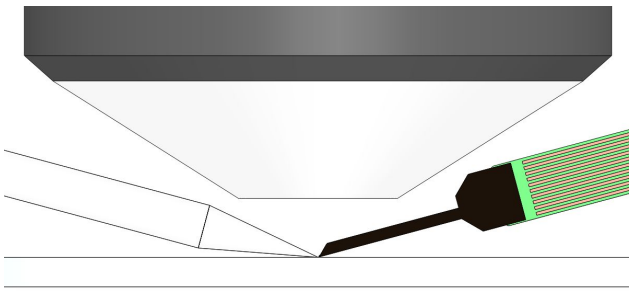
Piezoelectric actuation (PRPE)



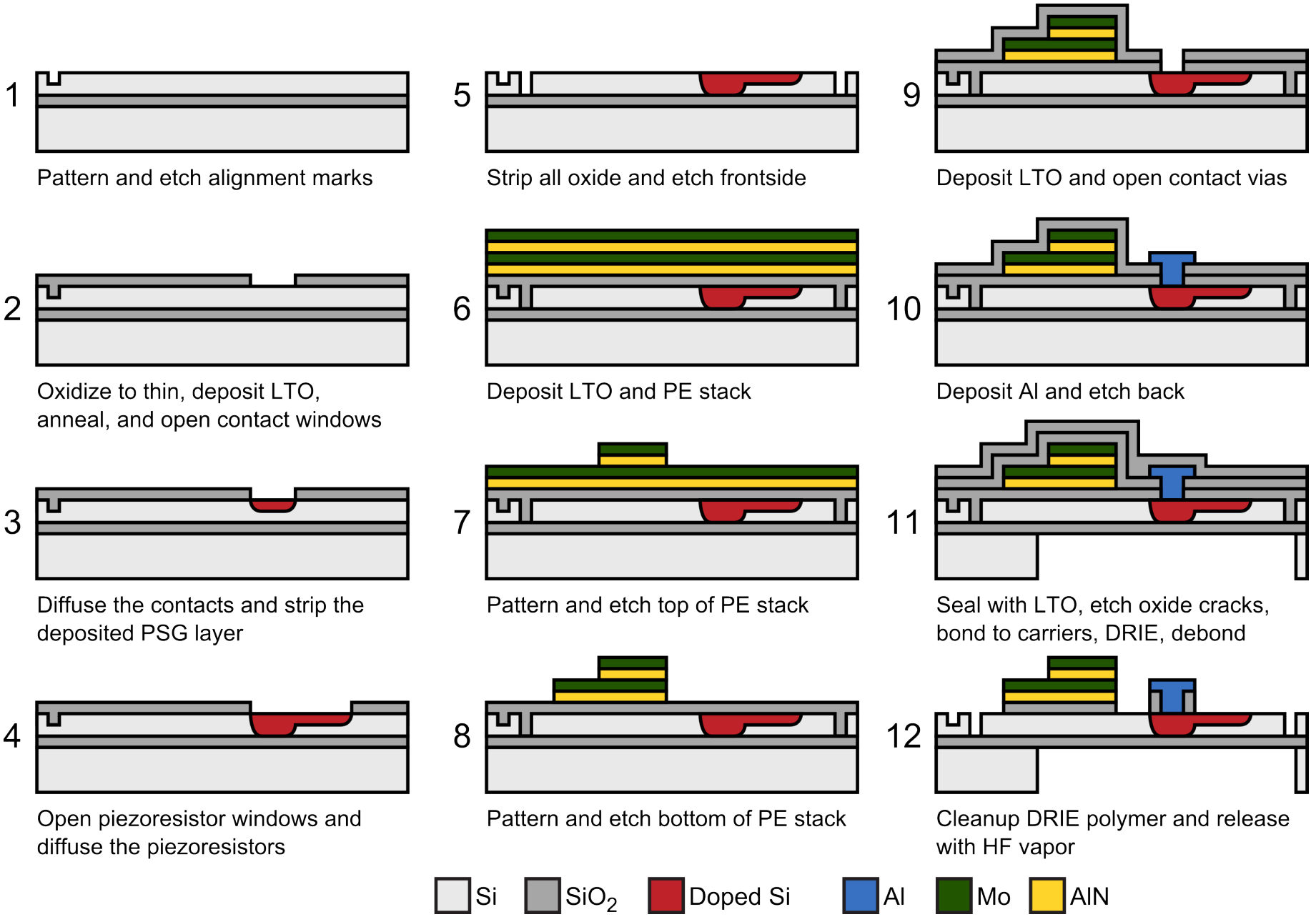
Thermal actuation (PRT)



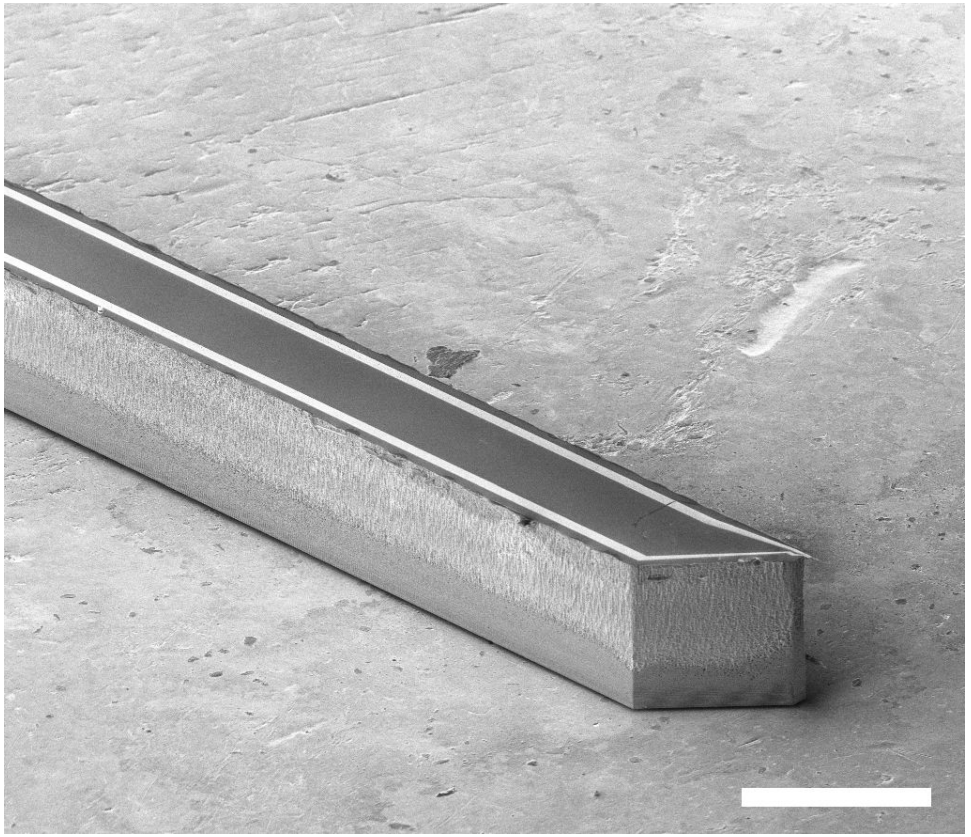


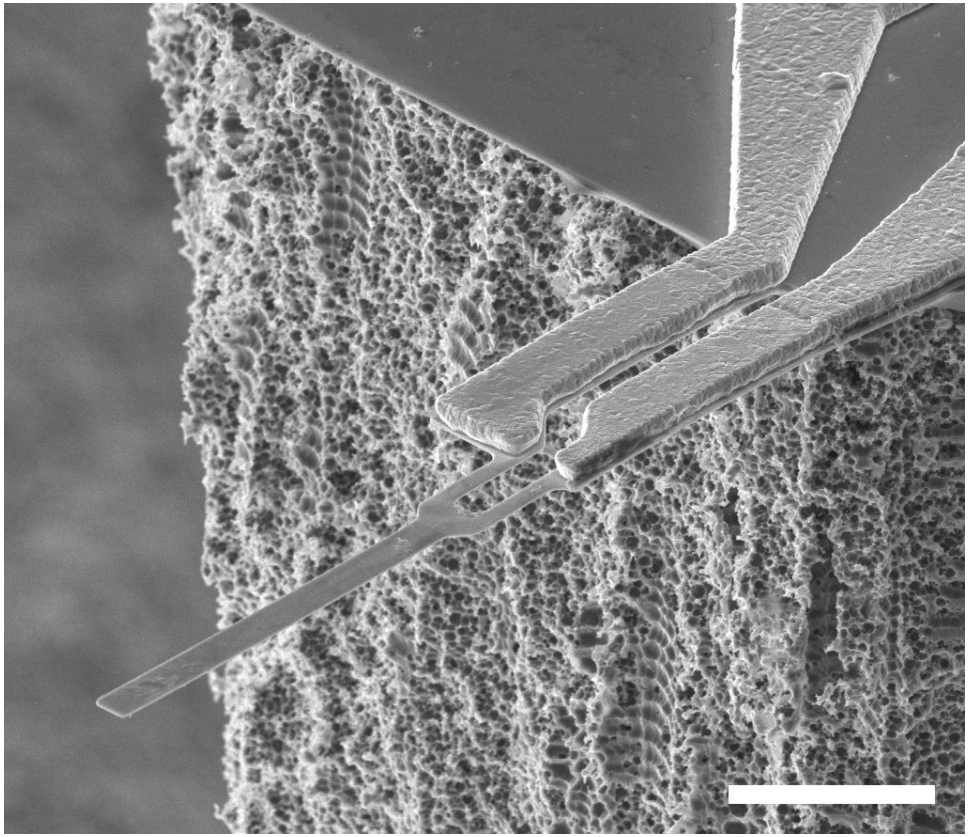


Probe Fabrication (PRPE)

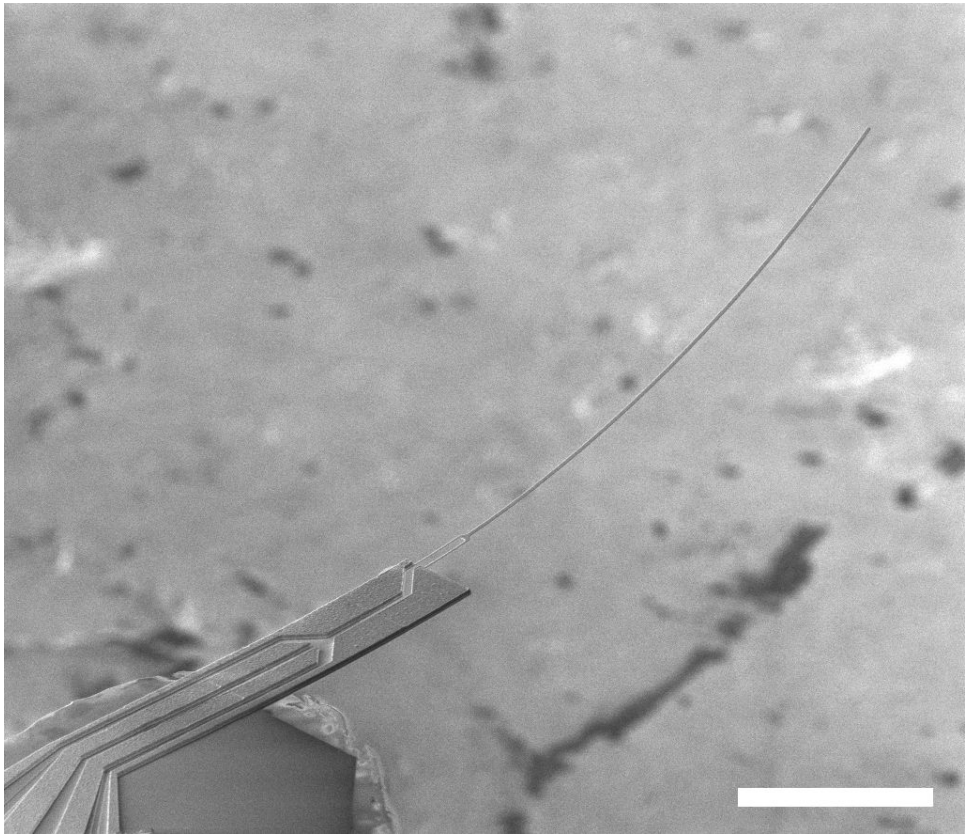


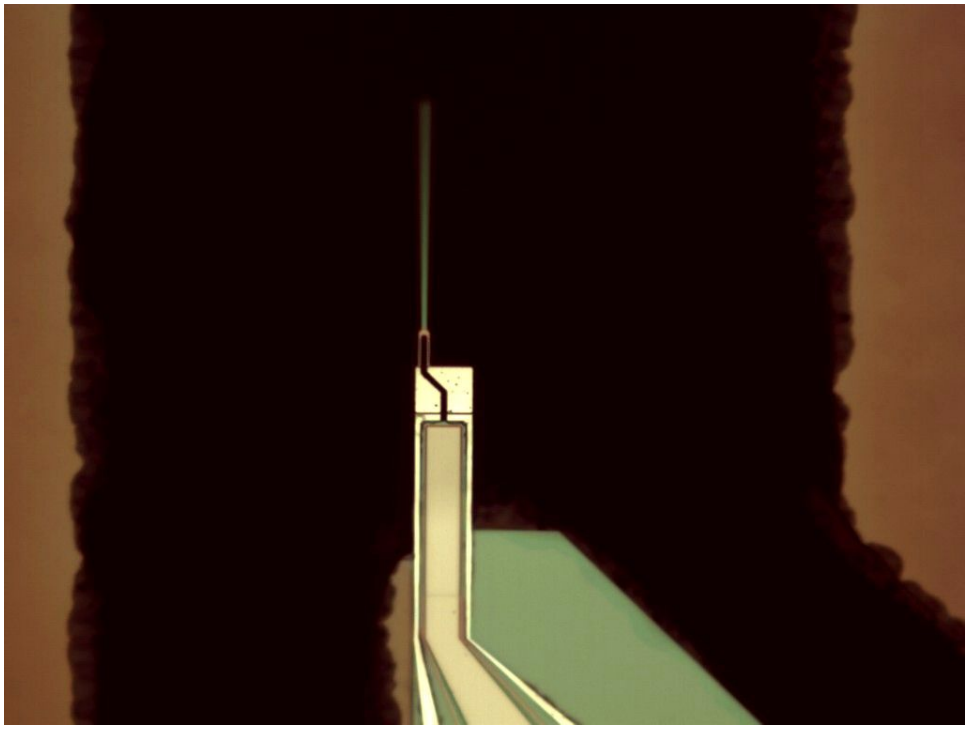
Finished Devices



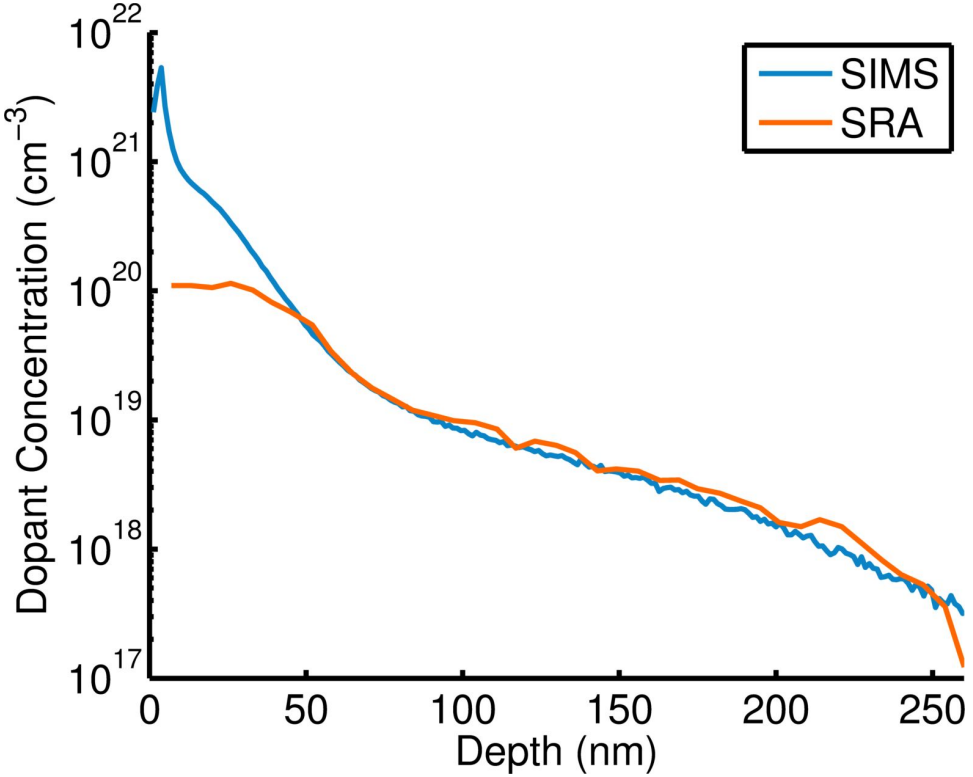


Finished Devices



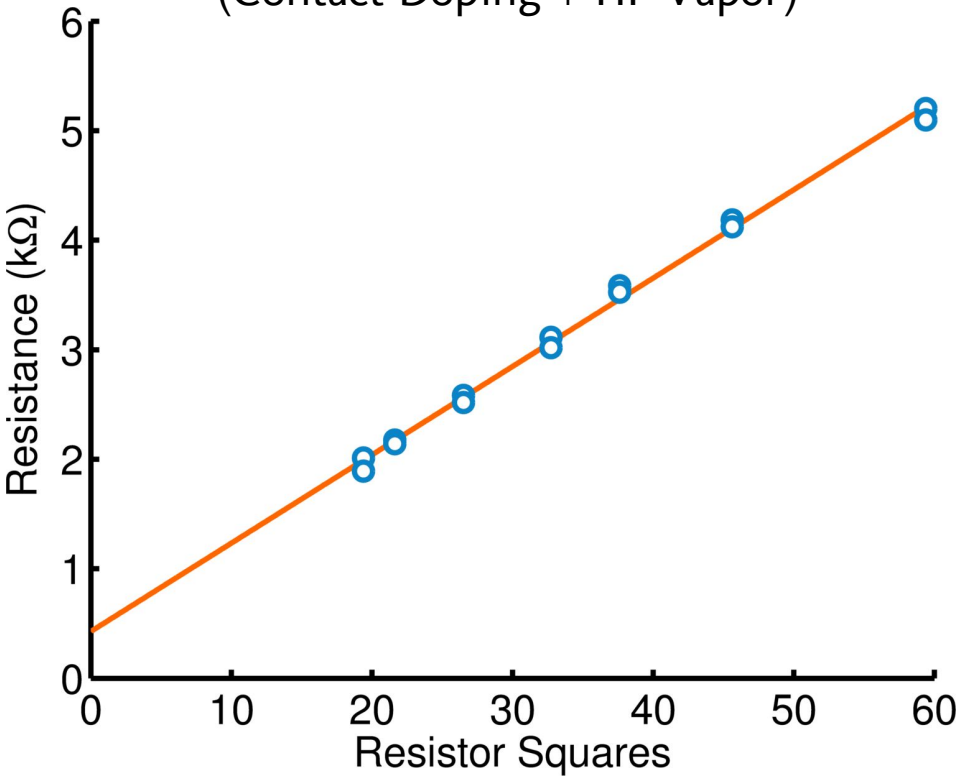


Piezoresistor Electrical Properties

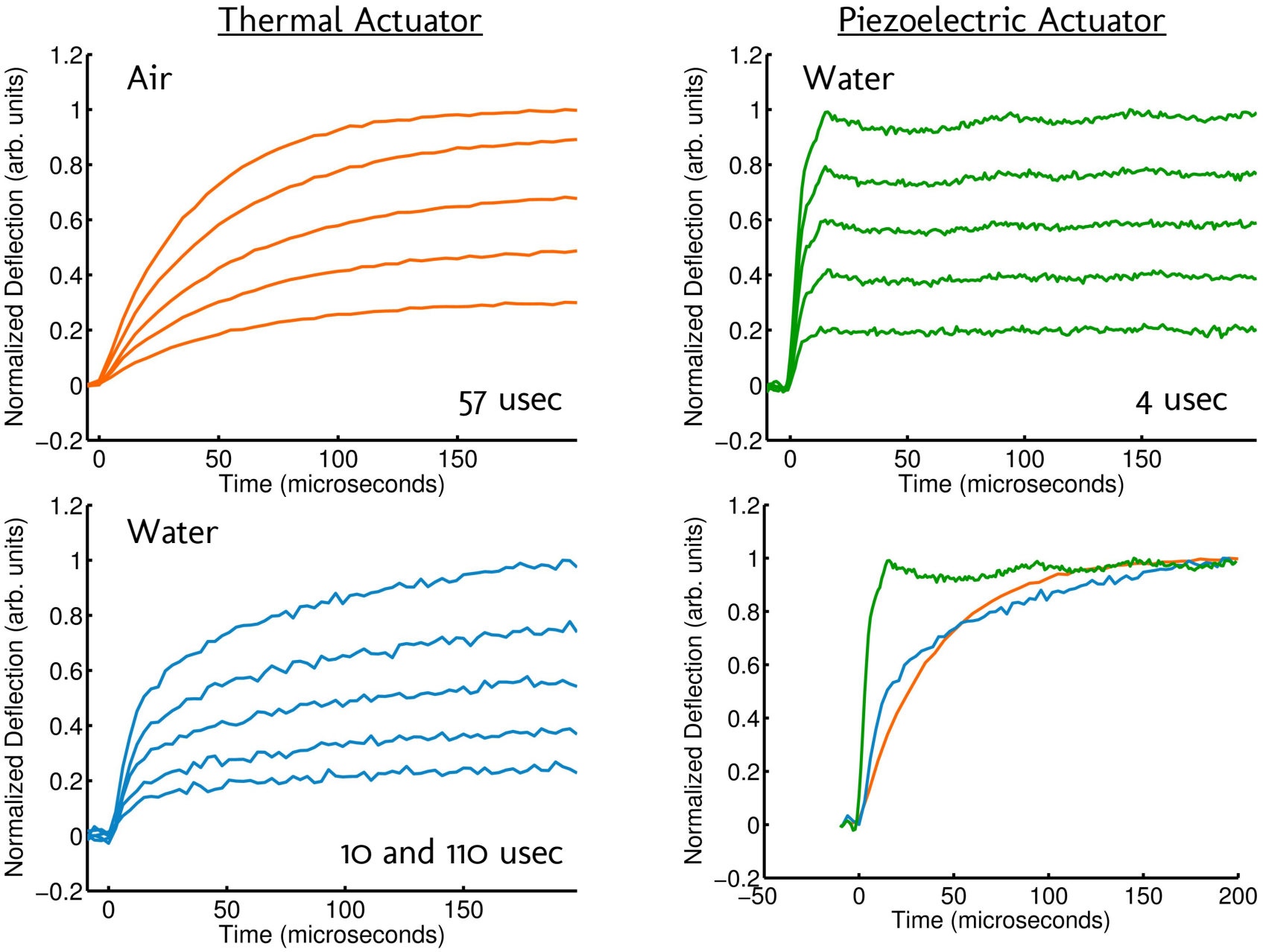


Single crystal Si, 800C/30min

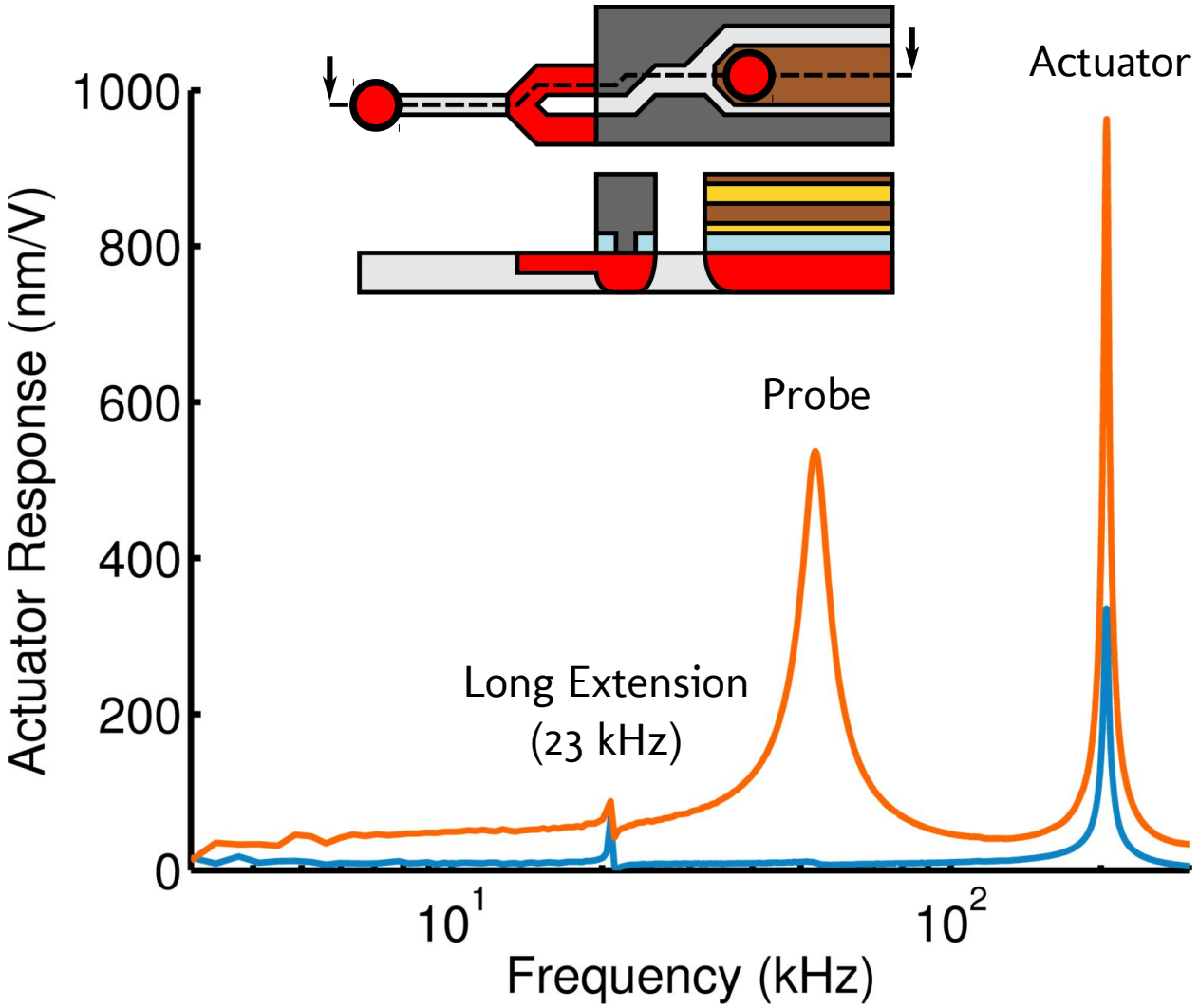
2011 Probes
(Contact Doping + HF Vapor)



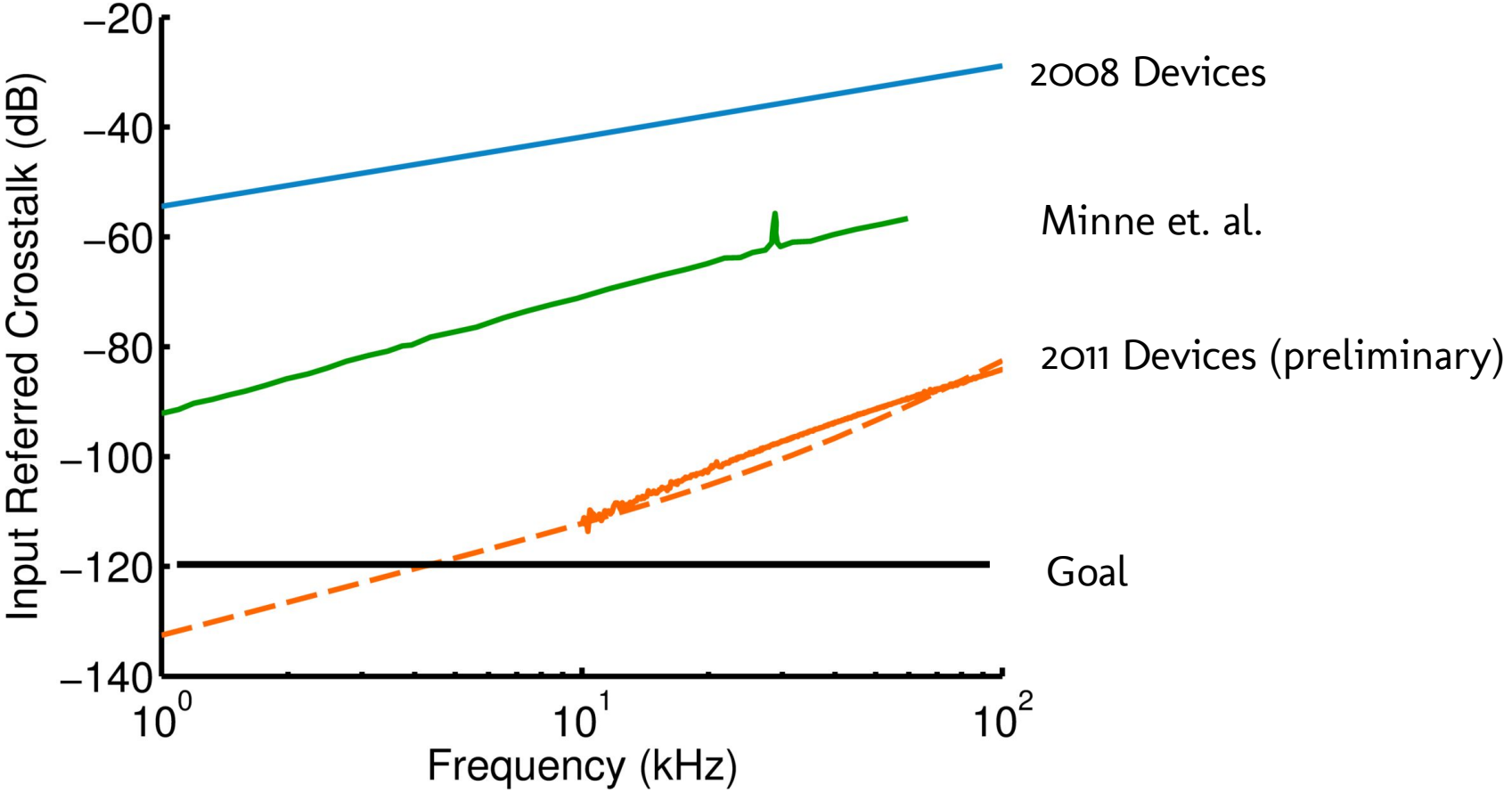
Actuator Step Response



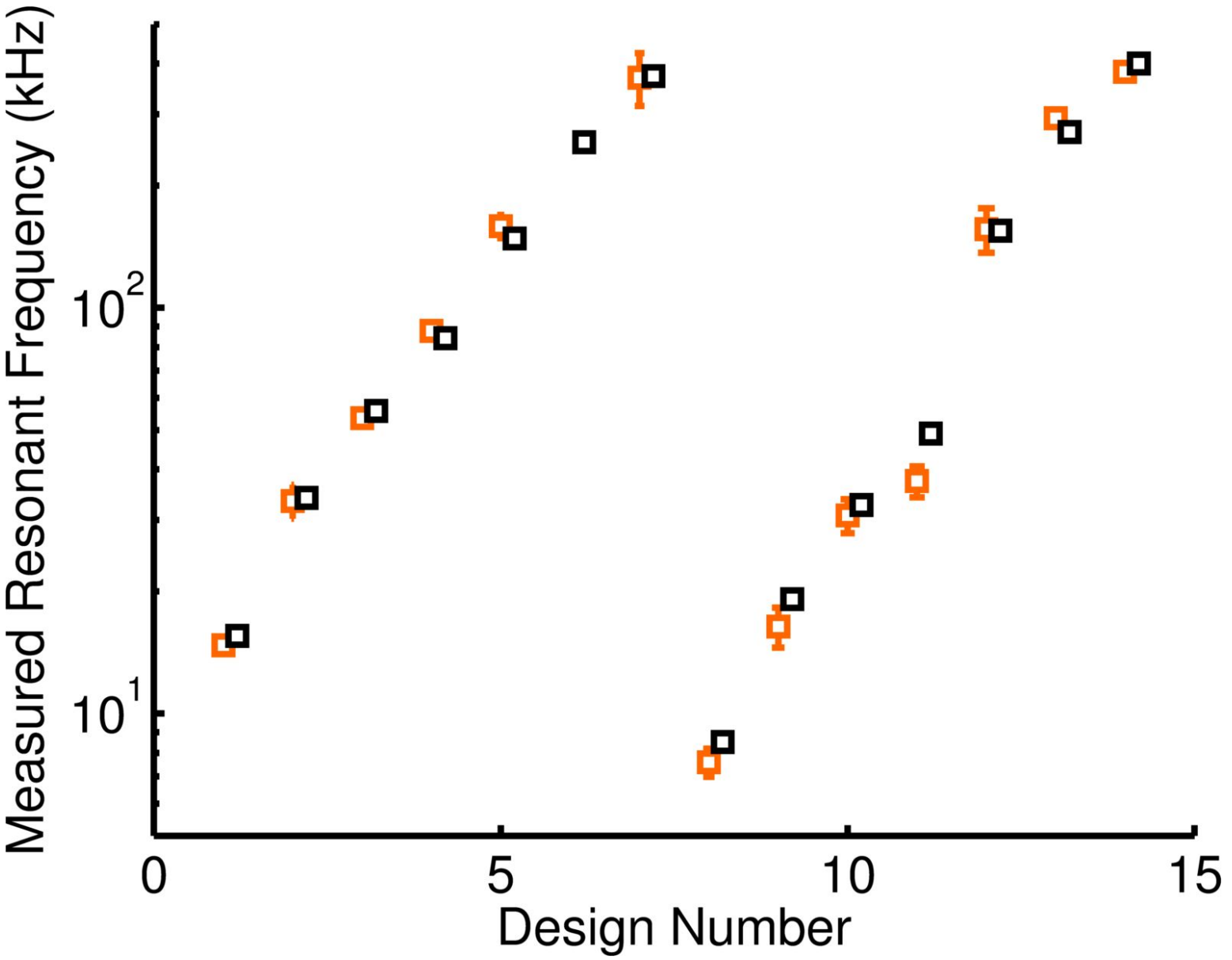
Actuator Frequency Response



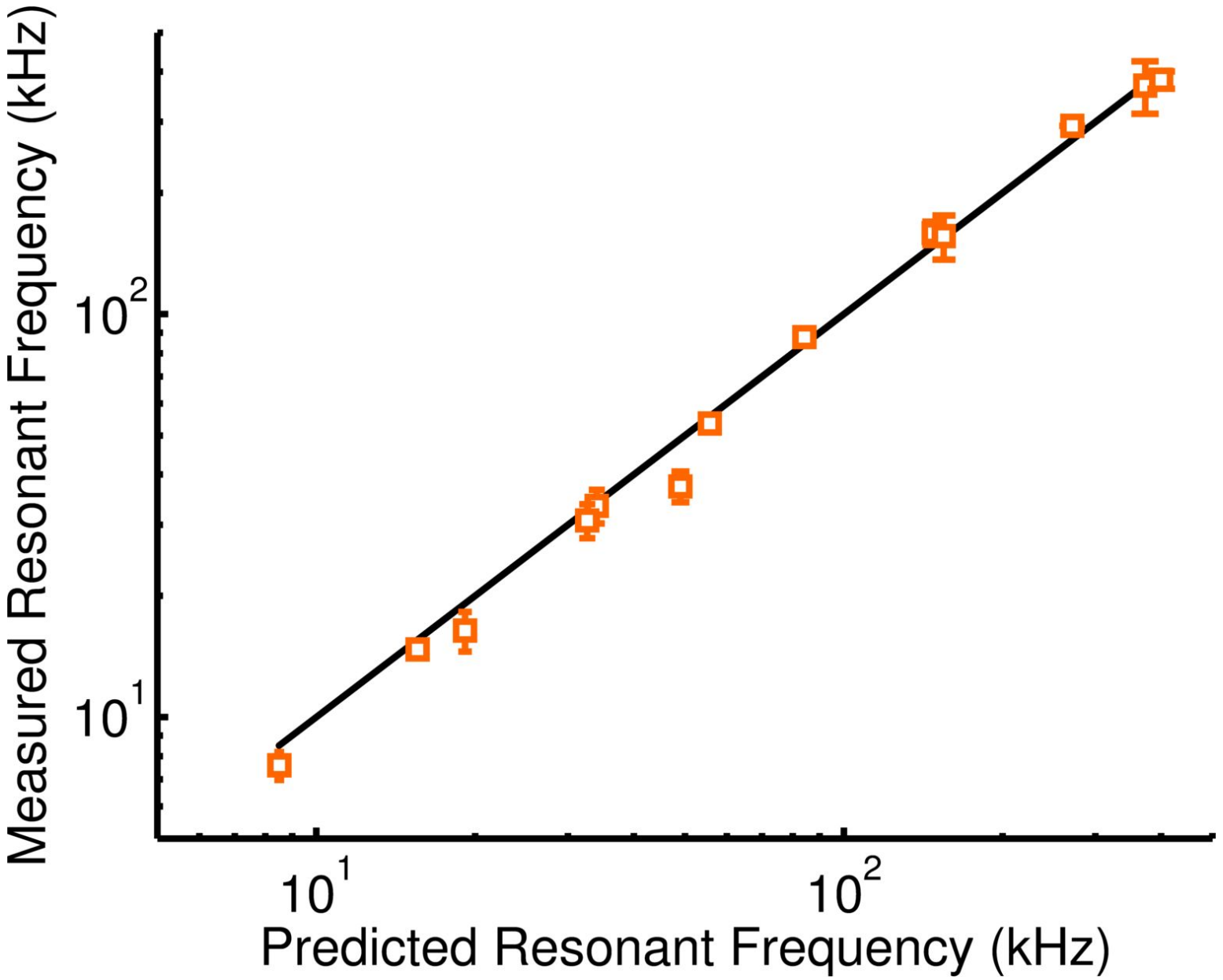
Capacitive Crosstalk



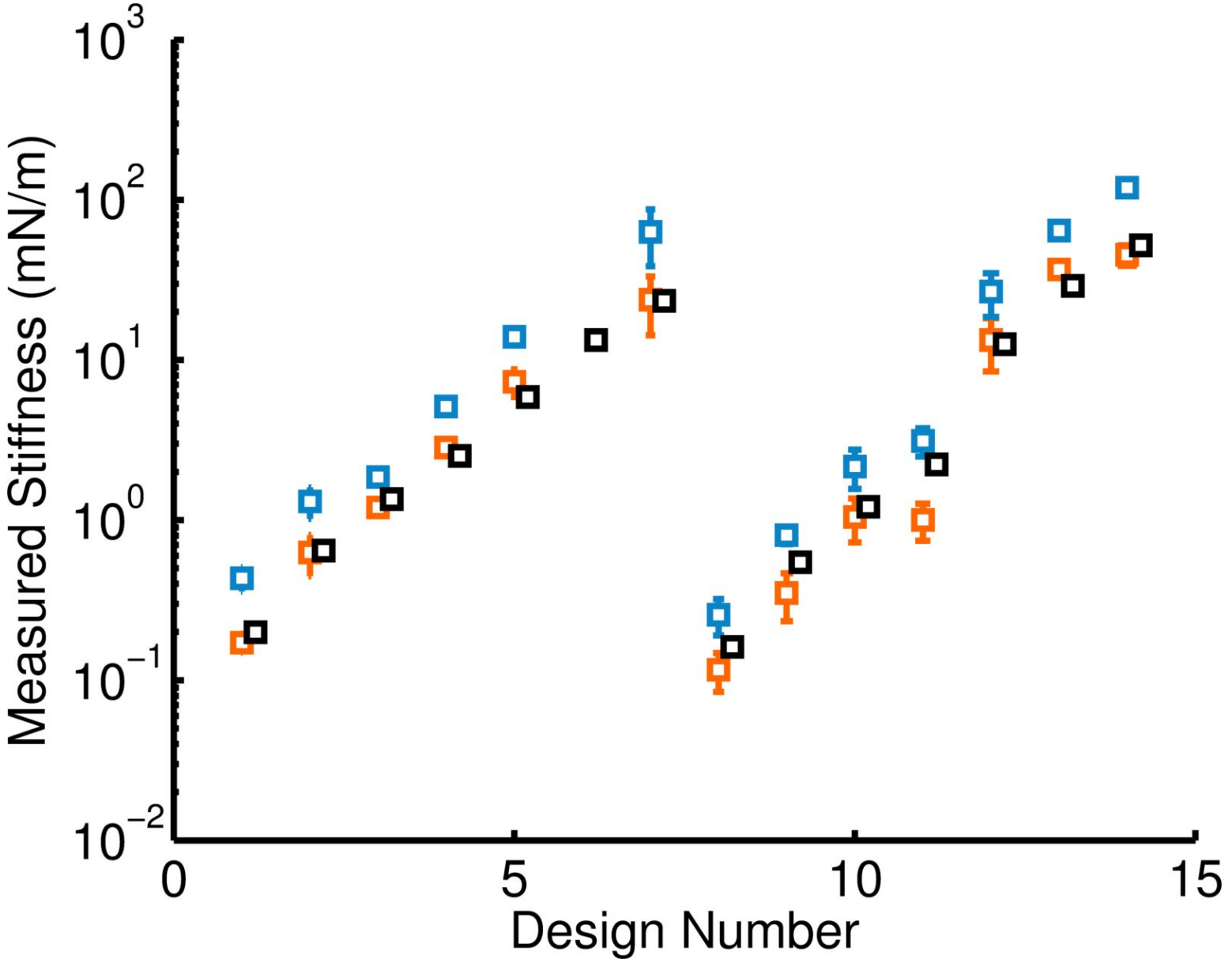
Resonant Frequency Data



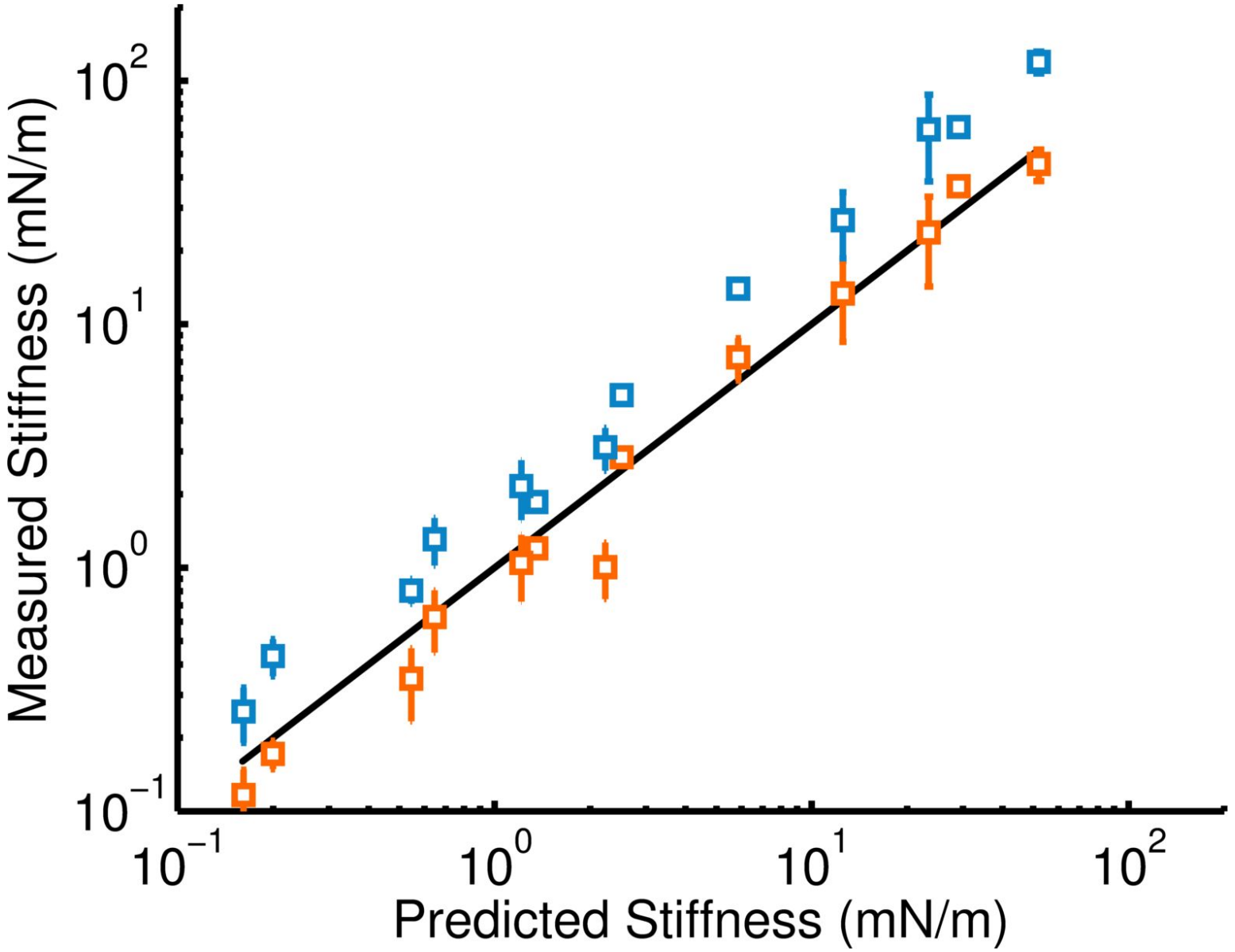
Resonant Frequency Data



Stiffness Data



Stiffness Data



Remaining Work

- Device characterization
  - Methods are fully developed. Currently testing more devices (at least 10–15 more)
  - Want to measure temperature via Raman (waiting on SNL training)
- Soft cantilever stiction upon exiting water
  - Plan on testing surface treatments
  - Discussions with Ginel Hill (who made < 0.1 mN/m probes) suggest O_2 plasma might work
- Hair cell experimental issues
  - Parylene coating is good as long as nothing touches it
  - Working on actuator-patch clamp crosstalk (alternative biasing and epoxy)
- Writing
  - Papers (device, methods)
  - Book (substantial overlap with the thesis)
  - Thesis (book work + experimental sections)