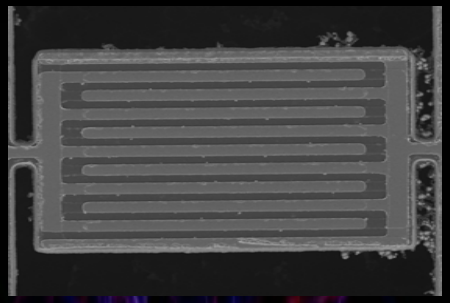
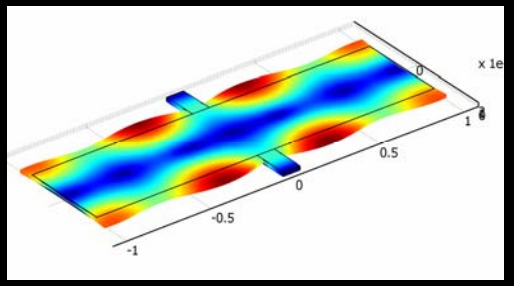


Modeling and Fabrication of Piezoelectric RF MEMS Resonators

Andrew Potter

SUNFEST 2007

Final Presentation



BROWN

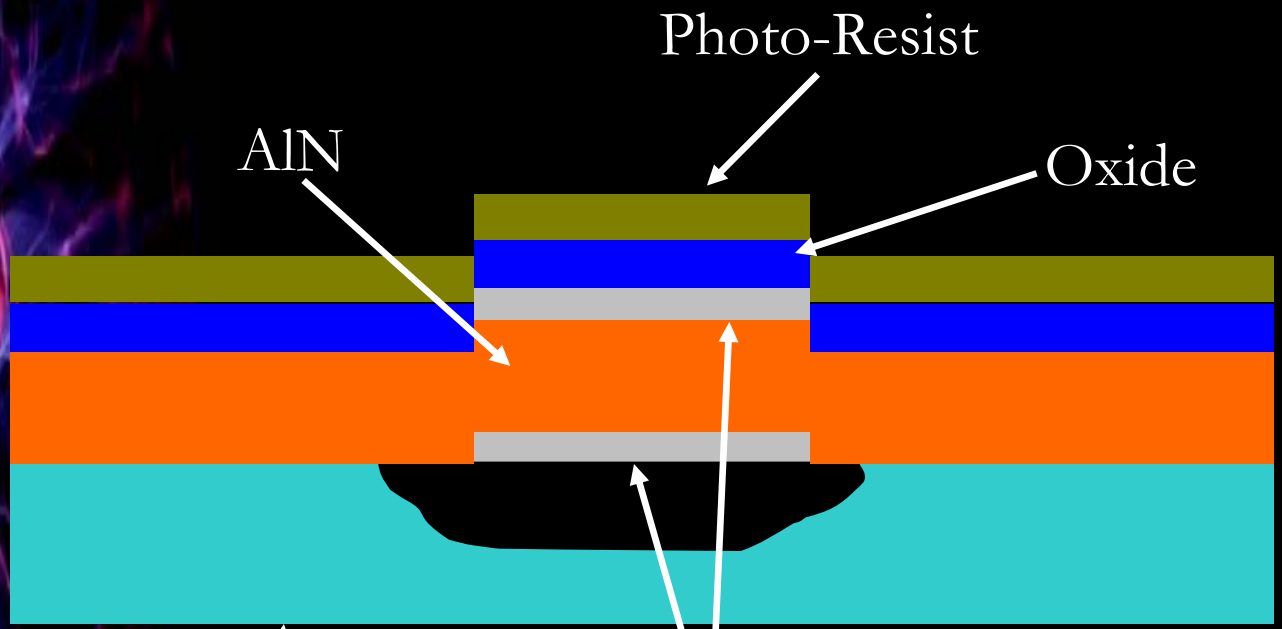
Project Goals

1. Optimize and Characterize ICP Etching
   a. Silicon Oxide Etching
   b. Aluminum Nitride Etching
2. Simulate the Effects of Non-Ideal Etch Profiles

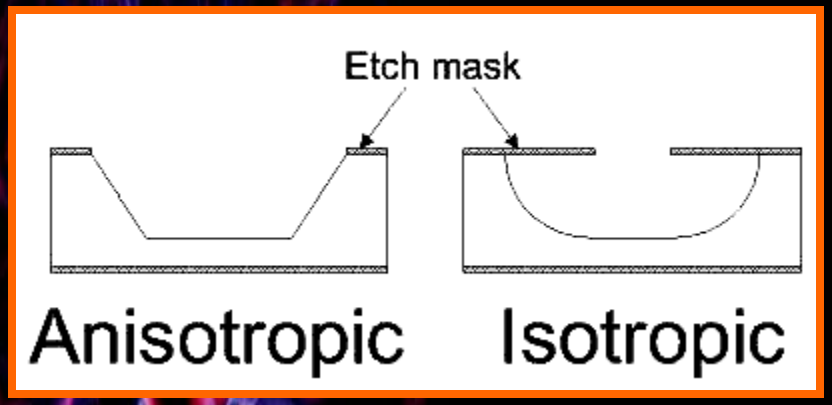
mrsec.wisc.edu/facilities/trionphantom.jpg

ICP Characterization

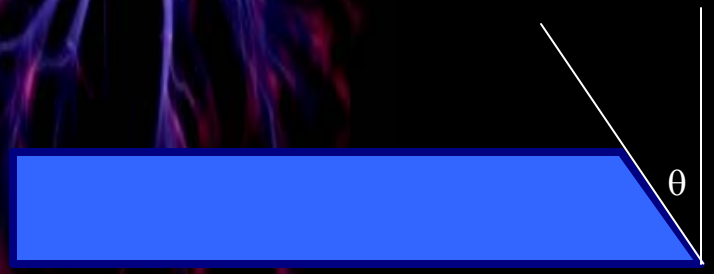
Fabrication Steps



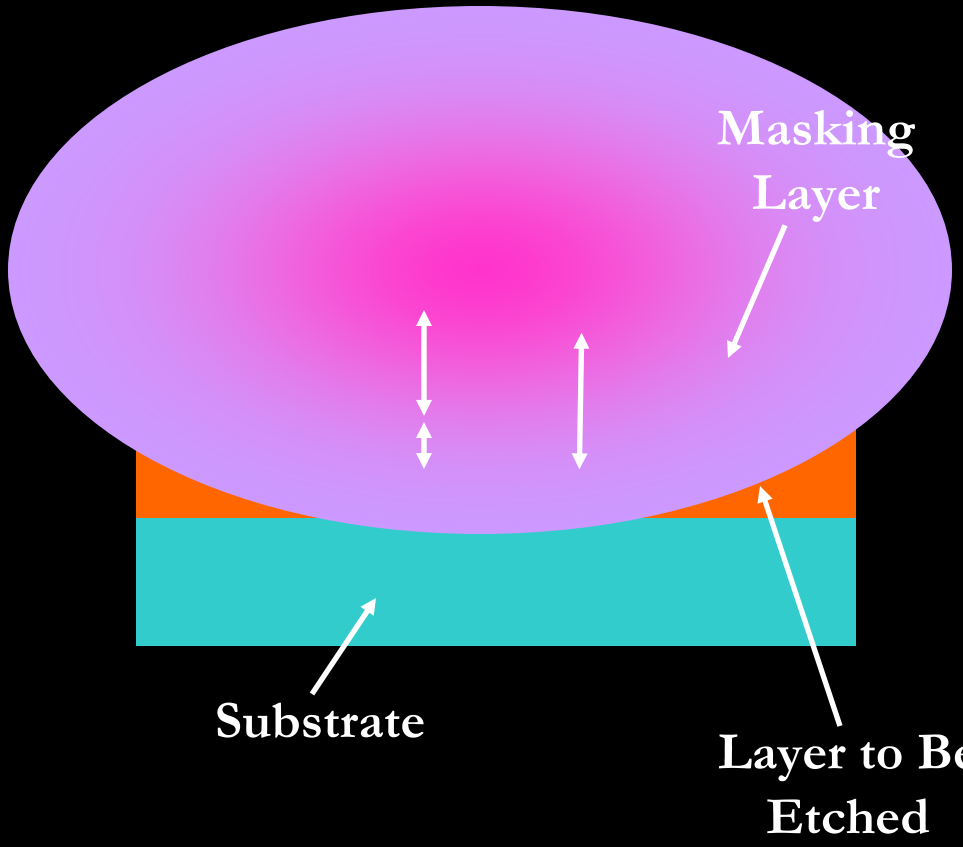
ICP Characterization



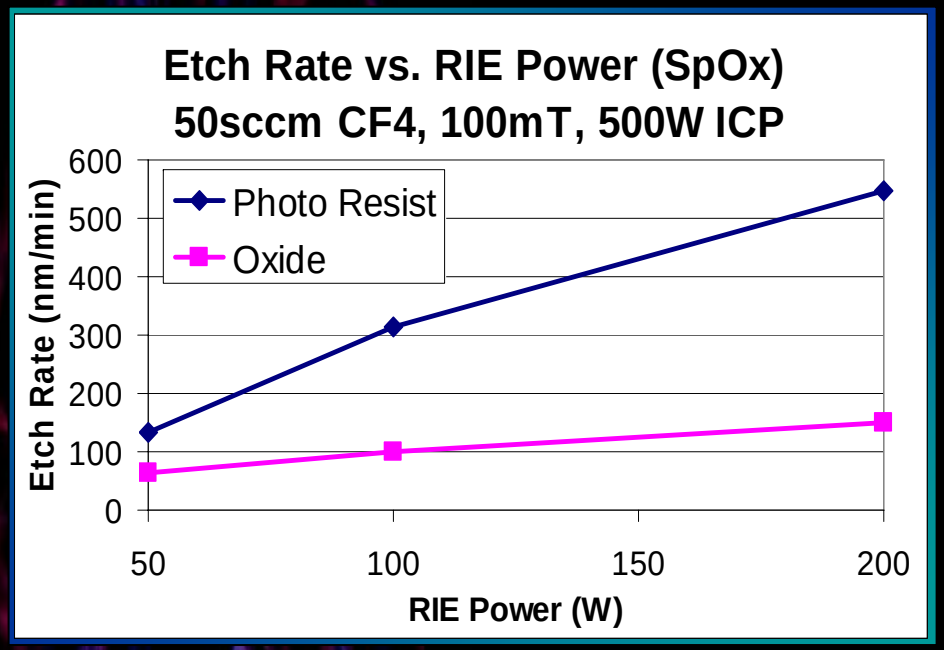
http://www.el-cat.com/images/silicon_etching.gif



Side-Wall Sloping

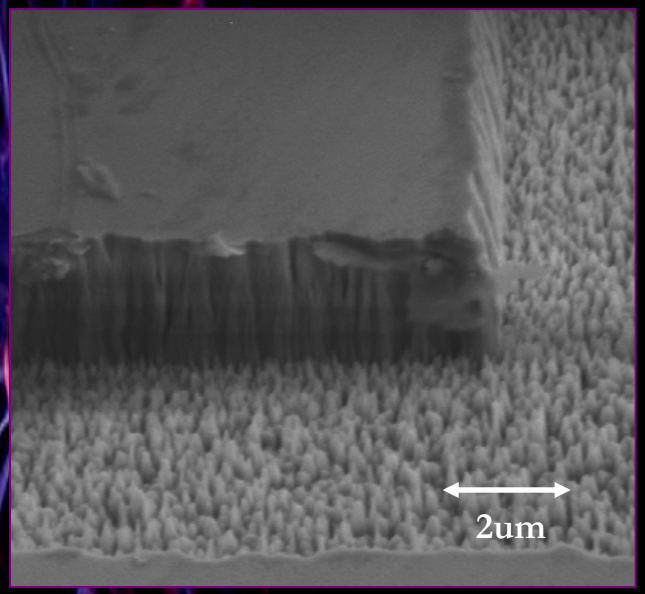


Oxide Etching



Best Selectivity Recipe:	
P: 100mT	Flow: 50sccm
RIE: 50W	ICP: 500W
Selectivity:	1:3 (Sputtered)
	1:4 (PECVD)
Oxide Rate: 50nm/min (SpOx)	
35nm/min (PECVD)	
Etchant: CF4	
Masking Layer: Photo-Resist	

AlN Etching

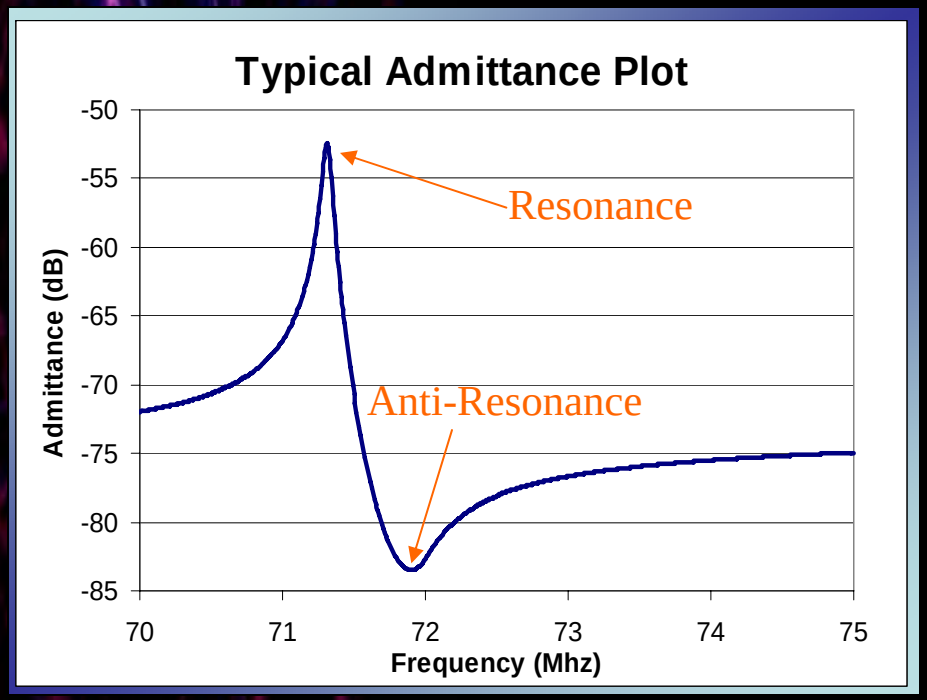


AlN Etch Profile
(SEM Micrograph)

Recipe Characterization:	
P: 100mT	BCl3: 25sccm
Cl2: 25sccm	Ar: 10sccm
RIE: 50W	ICP: 500W
Selectivity:	4:1 (SpOx)
	6:1 (PECVD Ox)
AlN Rate: ~200nm/min	
Etchant: BCl_3 Cl_2 and Ar	
Masking Layer: Oxide	

Modeling and Simulations

Figures of Merit



$$Y = 20\log_{10}\left(I/V\right)$$

Admittance

$$Q = \frac{f_{res}}{f_{3dB_2} - f_{3dB_1}}$$

Quality Factor

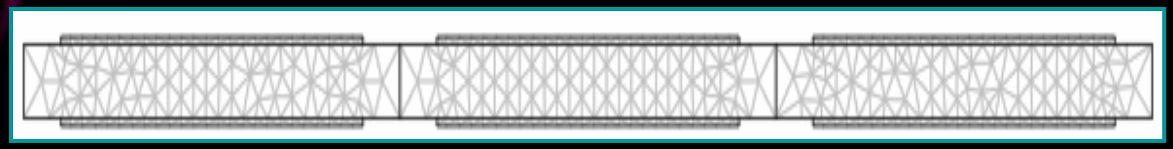
$$k_t^2 = \frac{\pi^2}{4}\left(\frac{f_{anti-res}}{f_{anti-res} - f_{res}}\right)$$

Efficiency

Simulation Methods

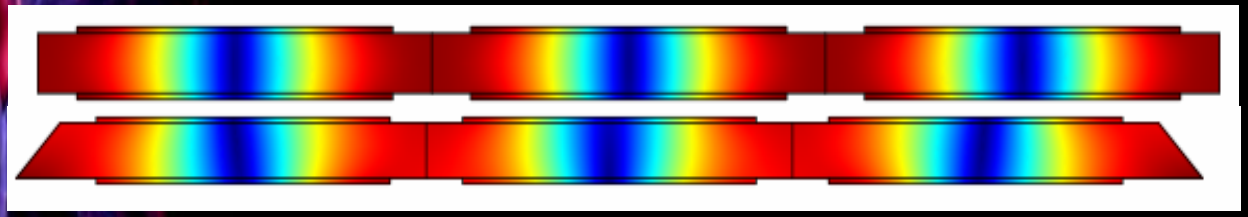
COMSOL Multiphysics (Piezo Plane-Stress)

Loss Factor Damping (η=1/1000)
Applied Voltage Amplitude: 1Vpp
Platinum Thickness: 200nm
(80% Coverage on Multi-Fingered Devices)

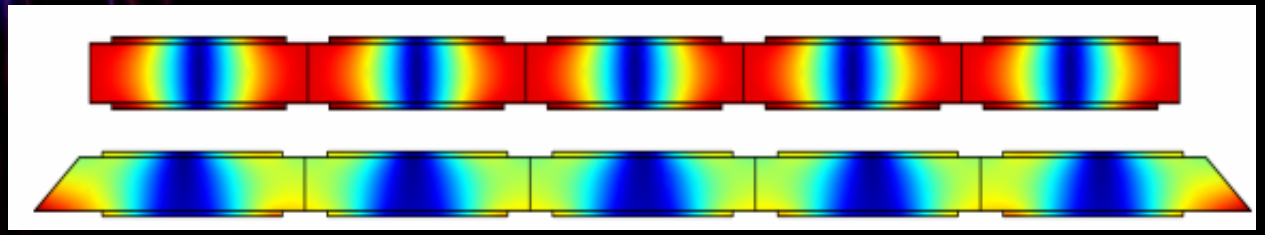


Mode Shapes

1-Fingered

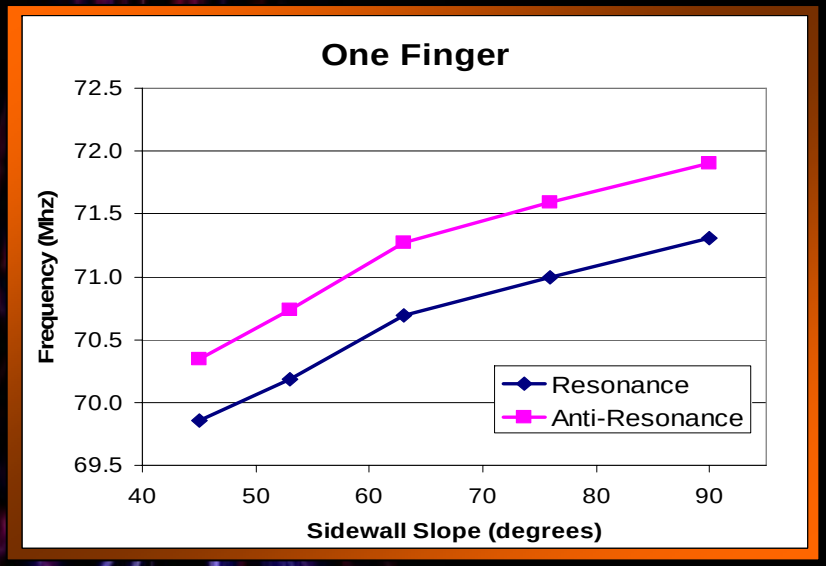


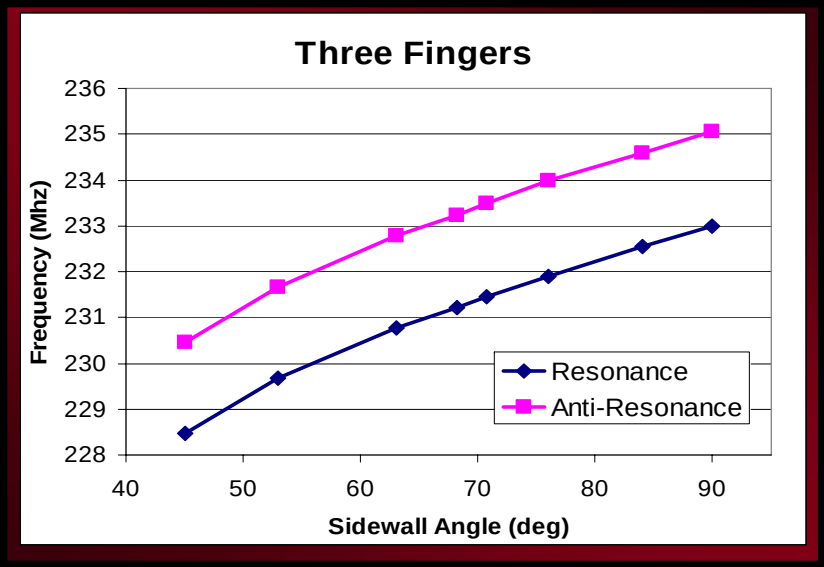
3-Fingered

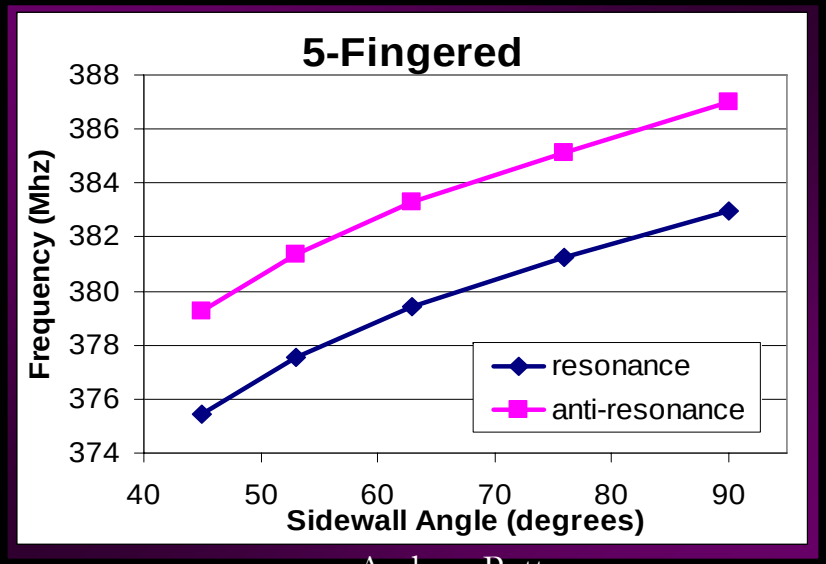


5-Fingered

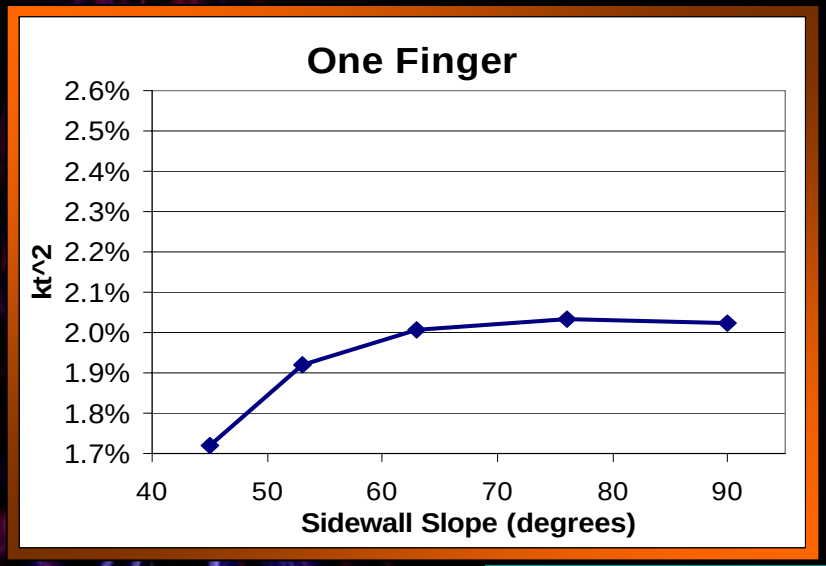
Frequency Shift vs. Sidewall Angle

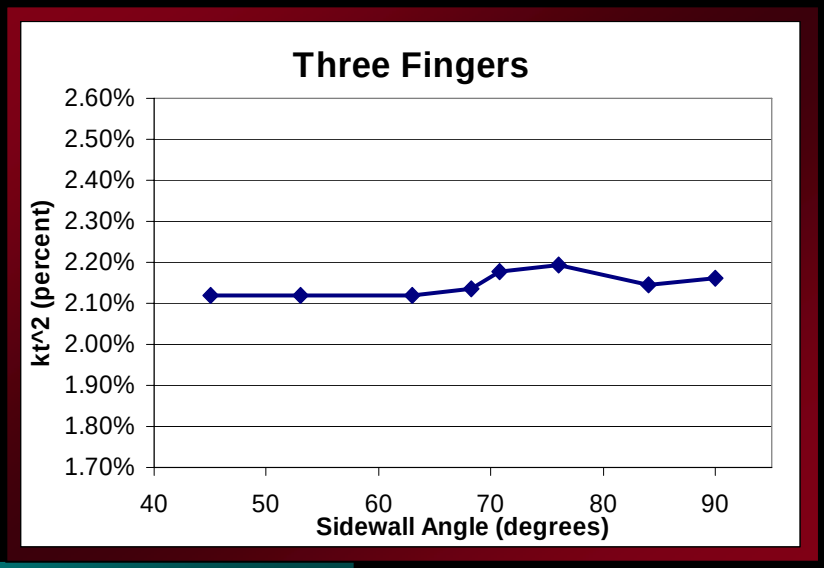


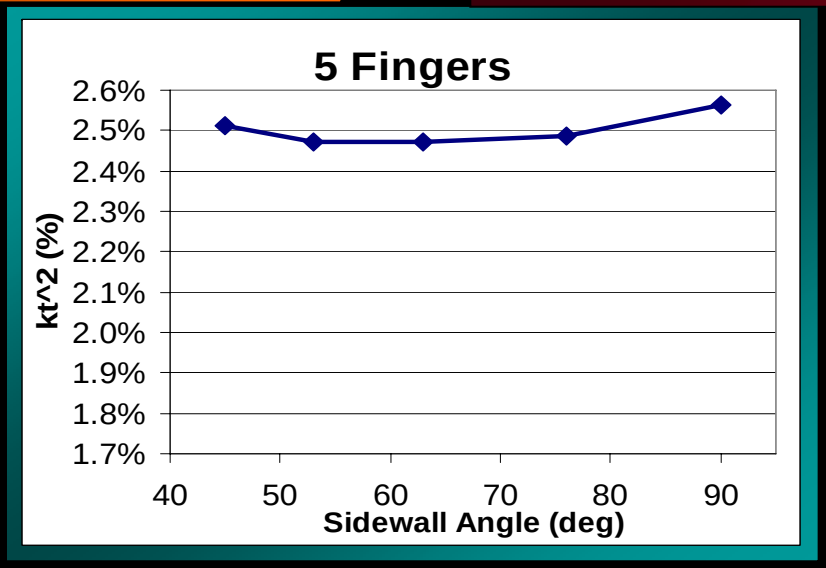




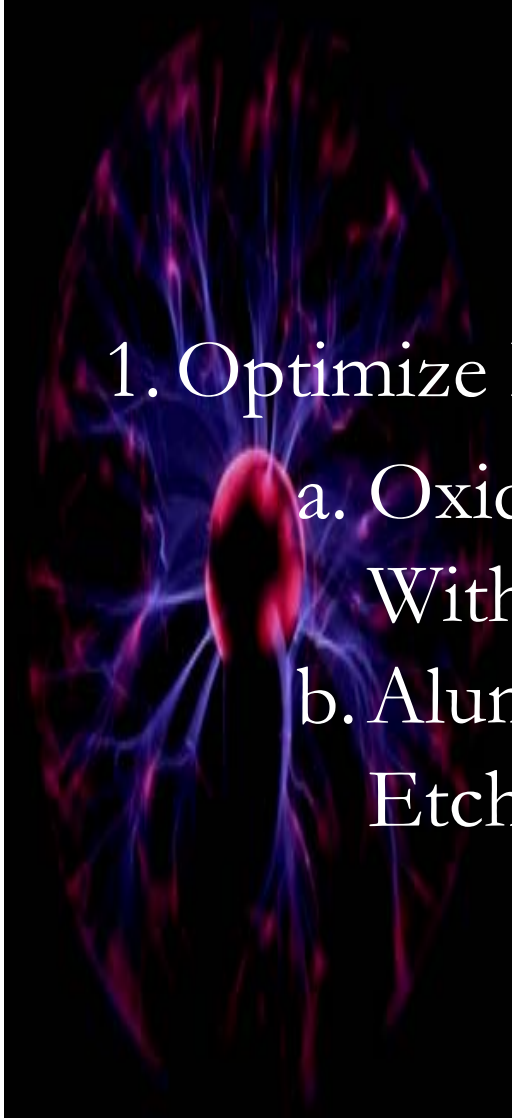
kt^2 vs. Sidewall Angle







What's Left



1. Optimize ICP Etching
    a. Oxide Etching – Want Higher Etch Rates Without Sacrificing Selectivity
    b. Aluminum Nitride – Try to Optimize Etching Profile

Thank you:

Adriane, Carlos, Nipun,
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NSF