IEEE SW Test Workshop

Semiconductor Wafer Test Workshop

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# Finite Element Modeling and Characterization of Cantilever Probe Tips Used in Wafer Test

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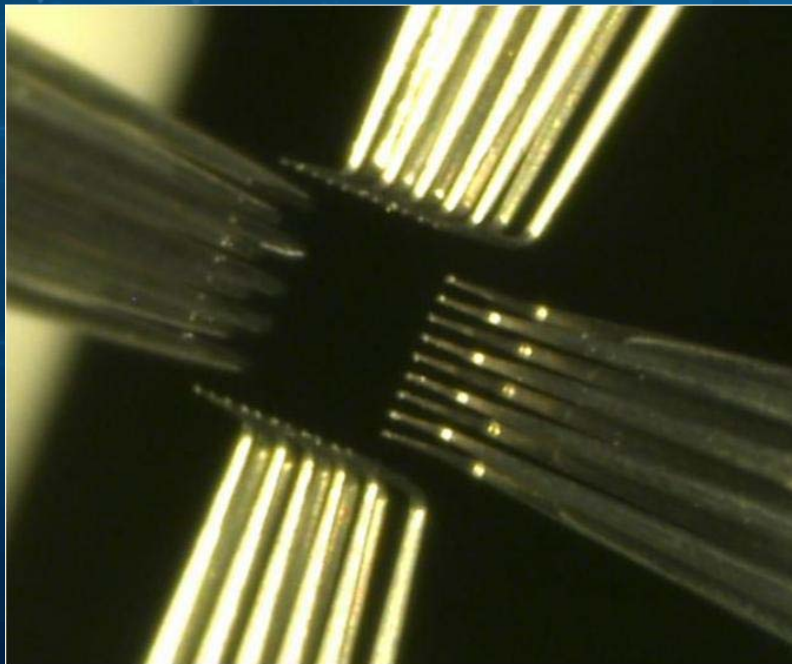
*This work supported by ON Semiconductor*

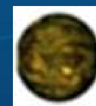
# Probing Experiment Factors

- **Input factors**
  - 3 probe cards (Standard force, Large tips, High force)
  - 3 wafers (Pad Al thickness: 0.7um, 0.9um, 3.0um)
  - No. of probe touchdowns (1 or 2)
    - Wafer stayed aligned between touches
  - Chuck overdrive
    - 50um, 100um
- **Probe mark measurements**
  - **Length of probe travel (scrub)**
  - (Total Area) Scrub area + Prow area
  - Depth (Remaining Al thickness)

# Probe Tip Characteristics per Card

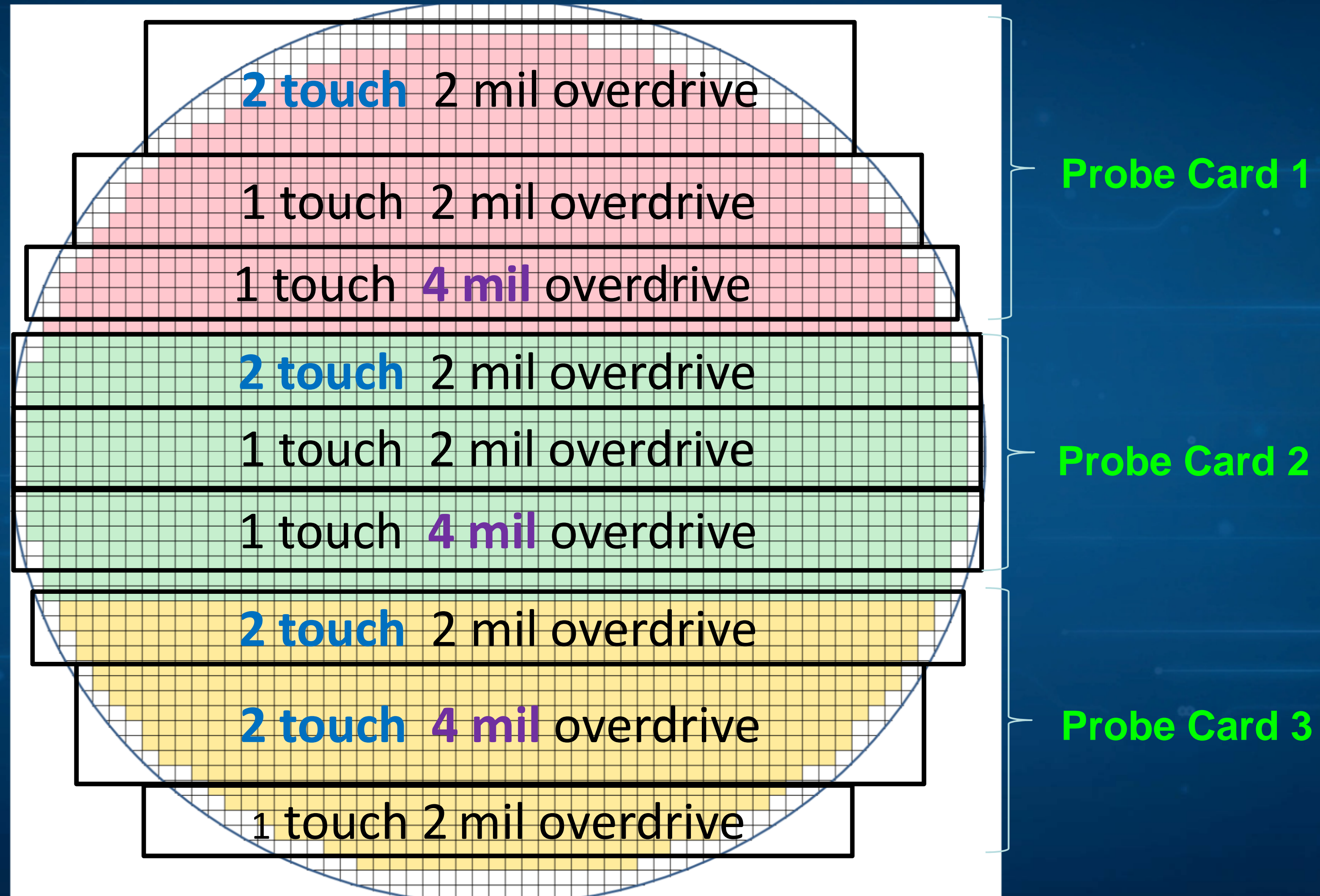
| | Probe Card 1 | Probe Card 2 | Probe Card 3 |
|---|---|---|---|
| Tip Diameter | .8 mil | **1.2 mil** | 0.8 mil |
| Force | standard | standard | **high** |





Example probe tip surfaces after use

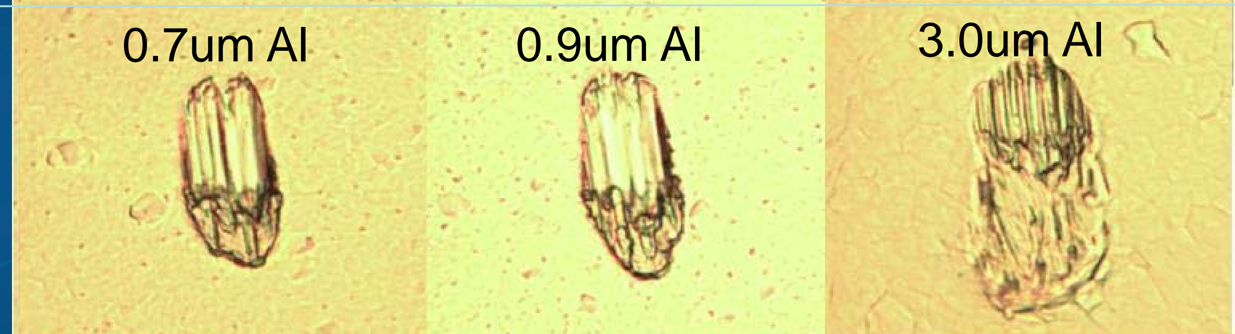
# Probing Experiment (3 wafers)



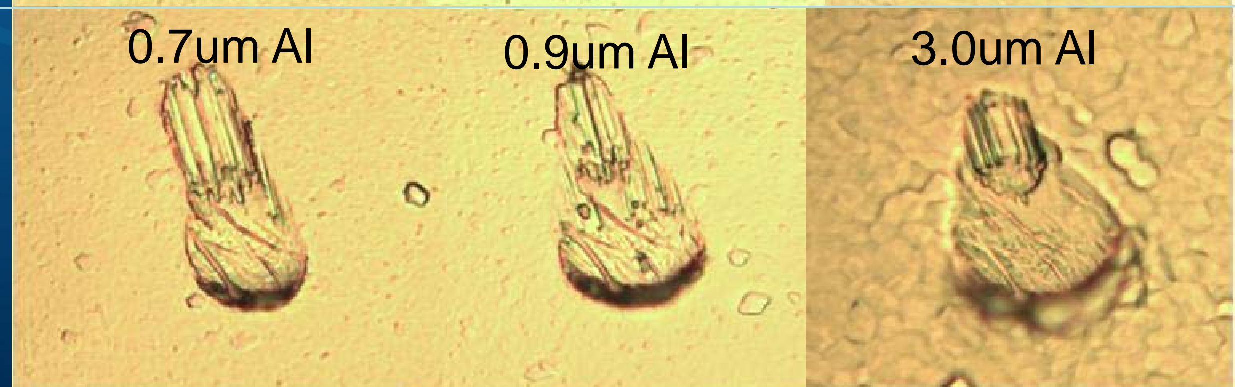
# Probe Marks: 1 Touch @ 2mils OD

- Standard Force Tip

- Large Tip

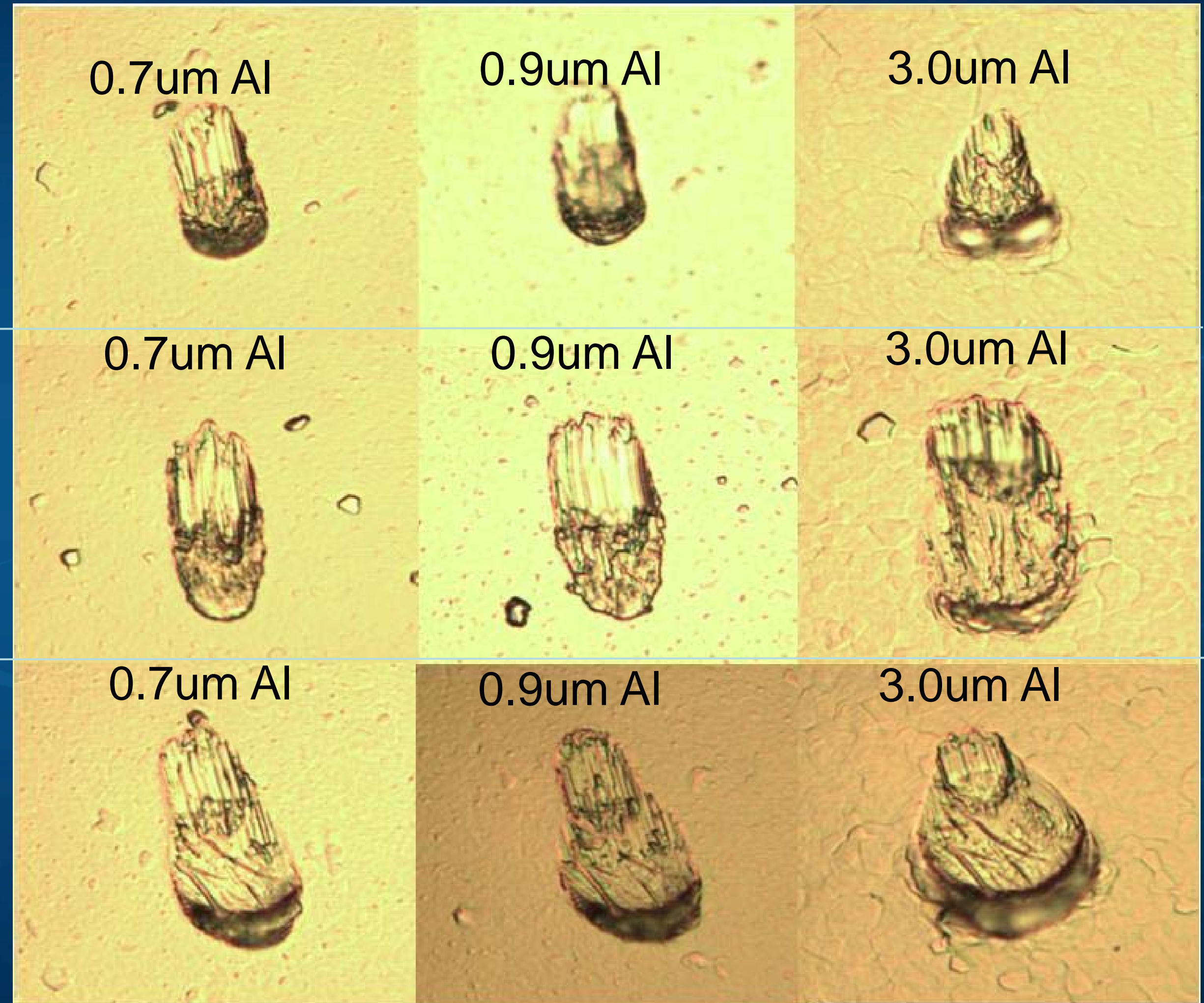



- High Force



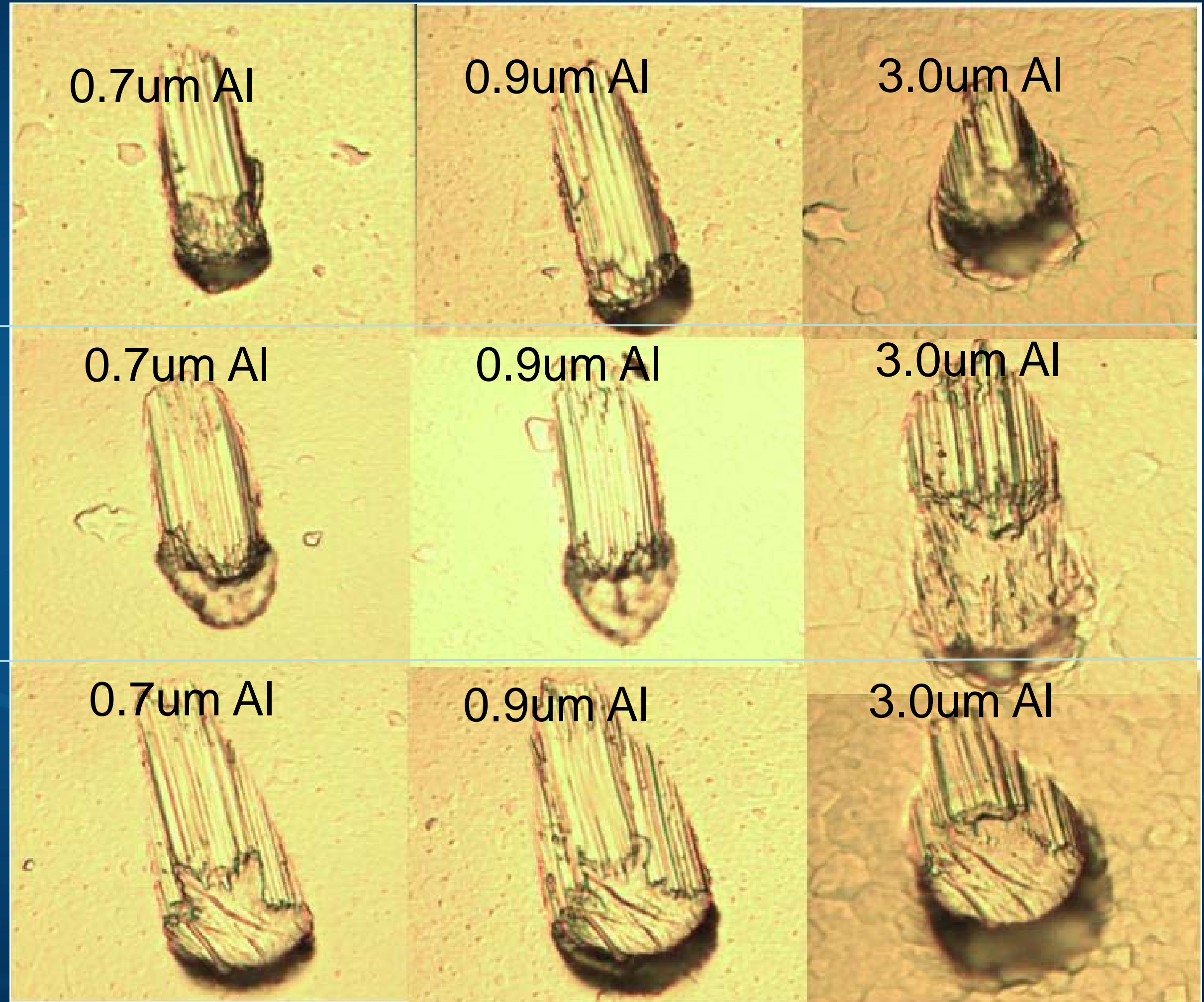
# Probe Marks: 2 Touch @ 2mils OD

- Standard Force Tip
- Large Tip
- High Force

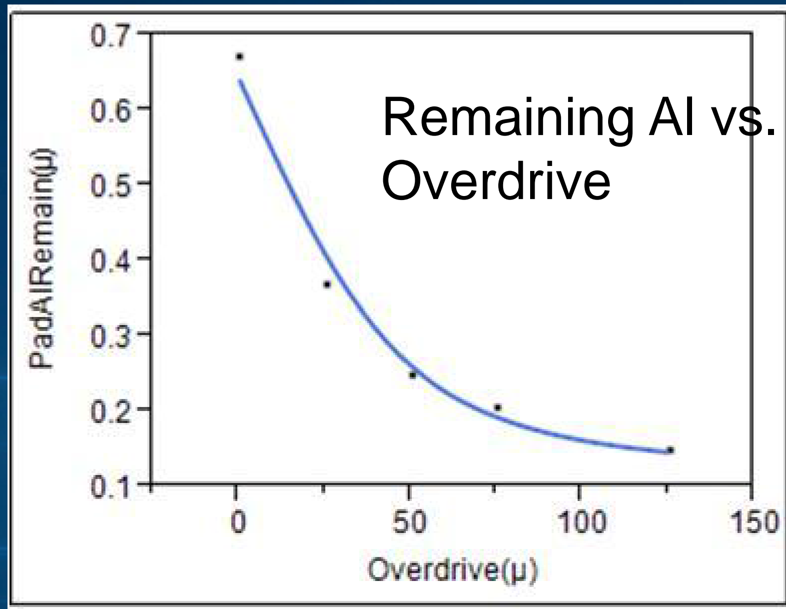


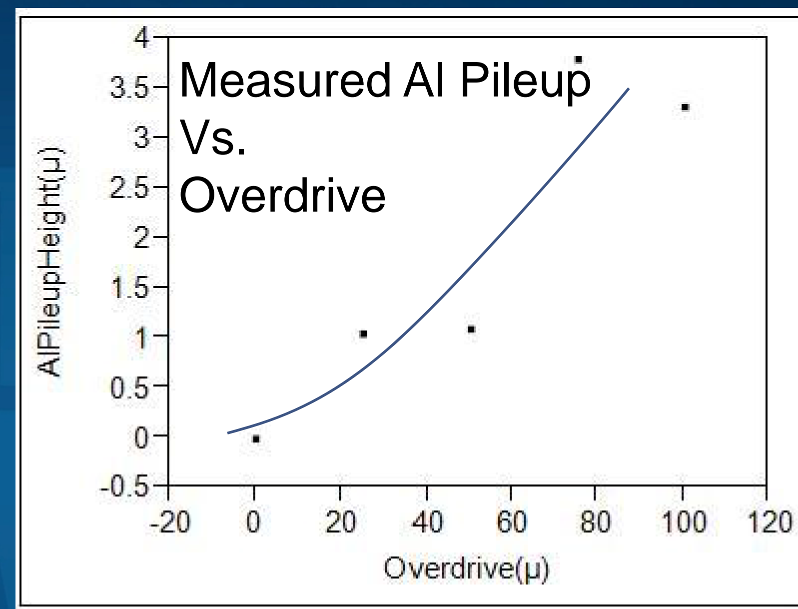
# Probe Marks: 1 Touch @ 4mils OD

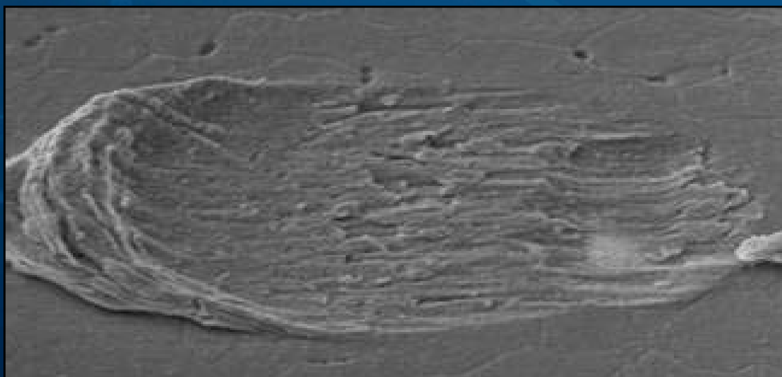
- **Standard Force Tip**
- **Large Tip**
- **High Force** (2 touches)

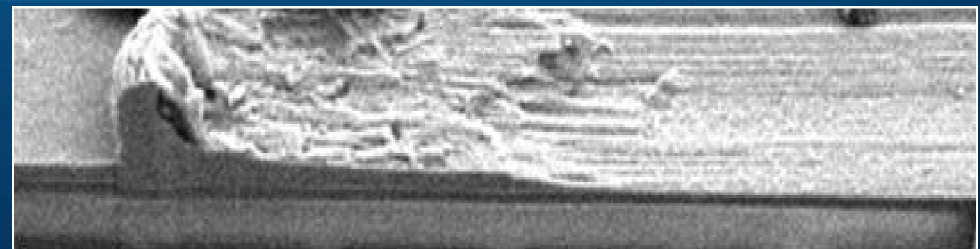


# Pad Al Remaining, Prow Height



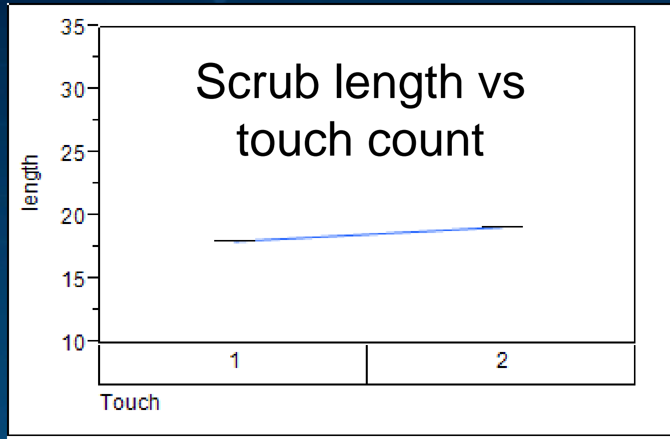



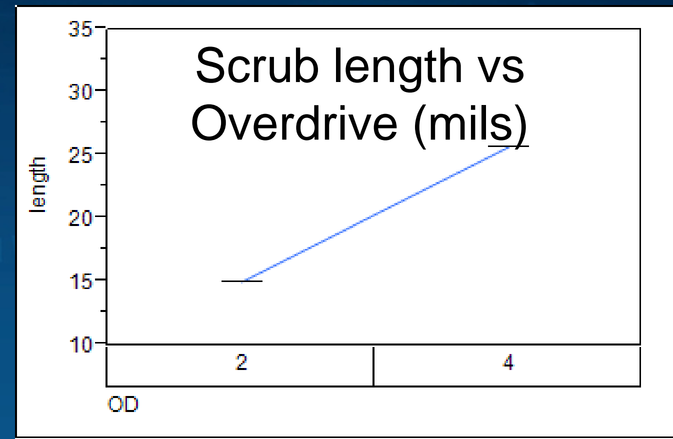


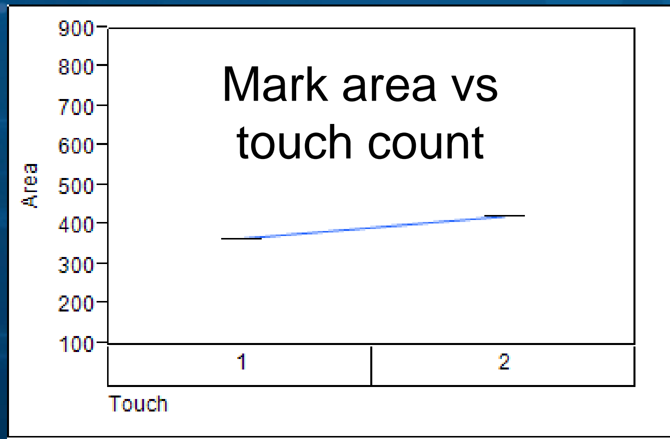
# Coincident Touches, and Overdrive

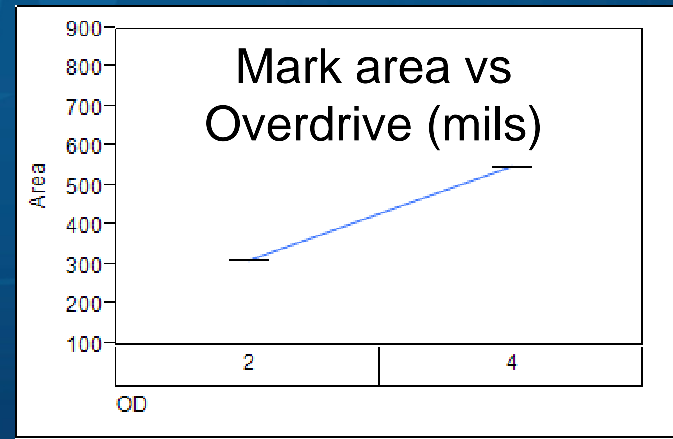
Tip Travel (um)

Mark Area ($um^2$)



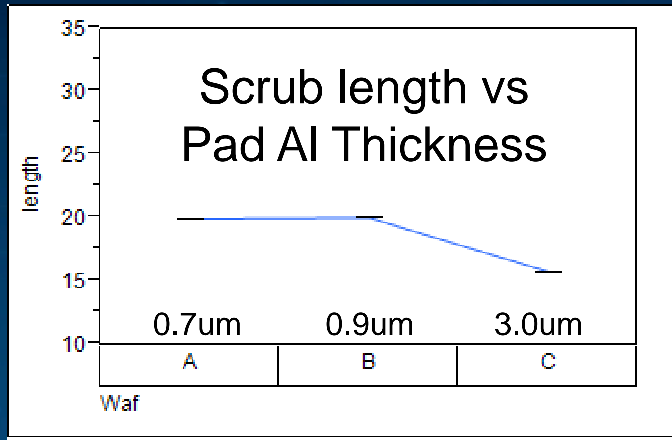



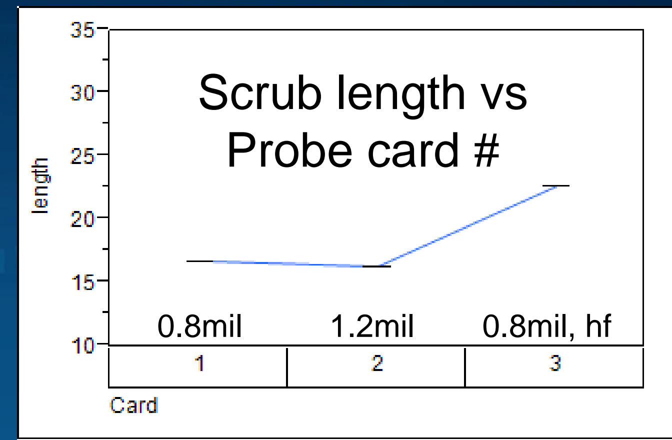

- Both Length and Area increase slightly with 2nd coincident probe touch

- Both Length and Area increase significantly with increased Overdrive

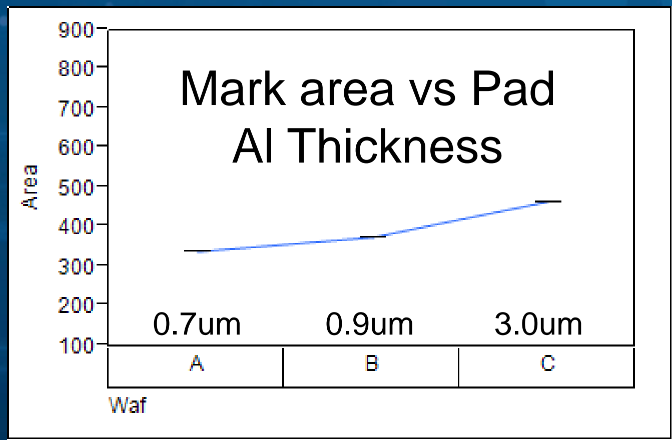
# Pad Al Thickness, and Probe Tip

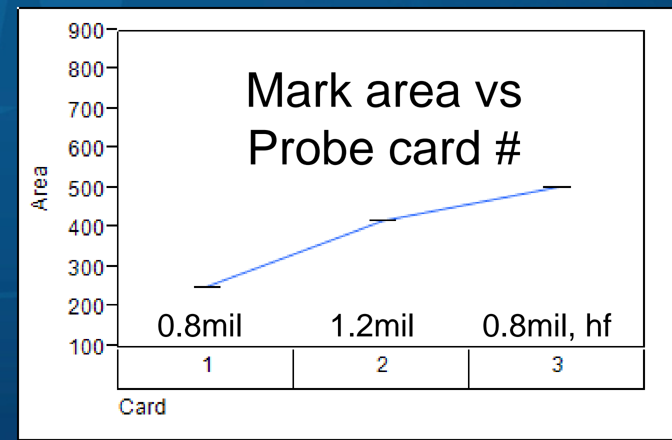
Tip Travel (um)




Mark Area ($um^2$)



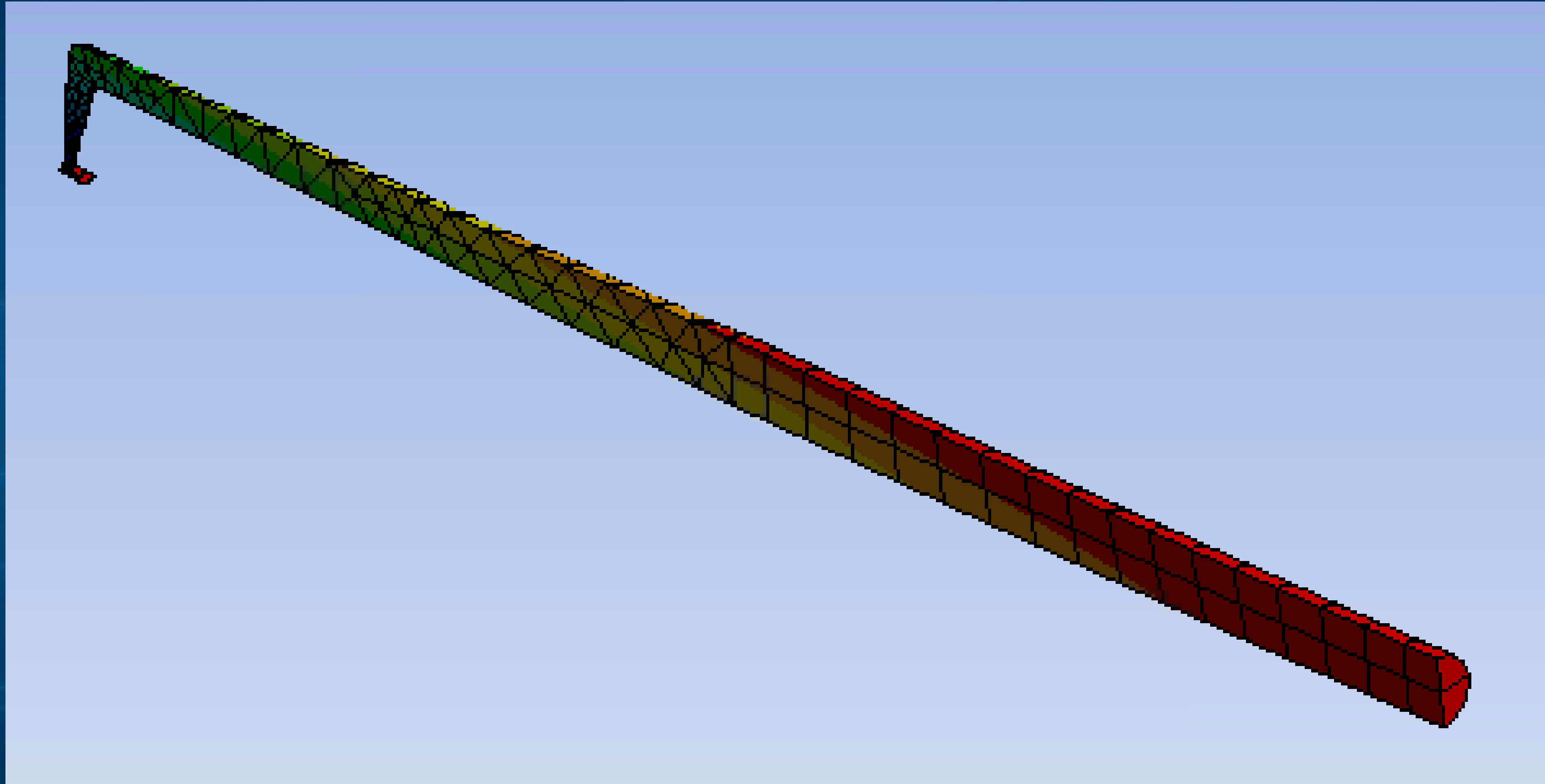

- Scrub Length decreases with pad Al thickness, while Area decreases

- Larger tip doesn't change Scrub Length, but increases the Area
- High force probes increase Length *and* Area

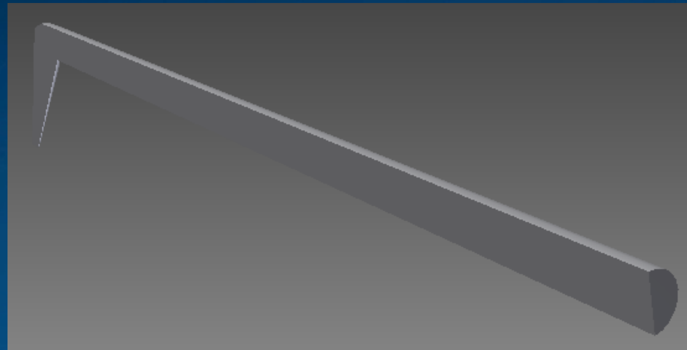
# Finite Element Models of Probe Tips

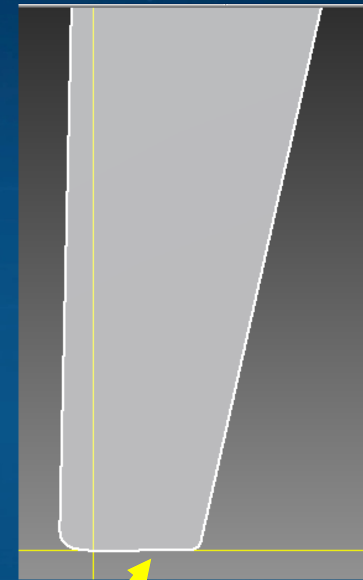
- Student-created probe tip models are used to simulate the scrub motion of probing
- Experimental data above is used to check the validity of modeling
- *Objective is to learn from modeling how to reduce probe mark size and probe longevity without causing pad or bondability issues*
- Preliminary results follow:

# Finite Element Model of Probe

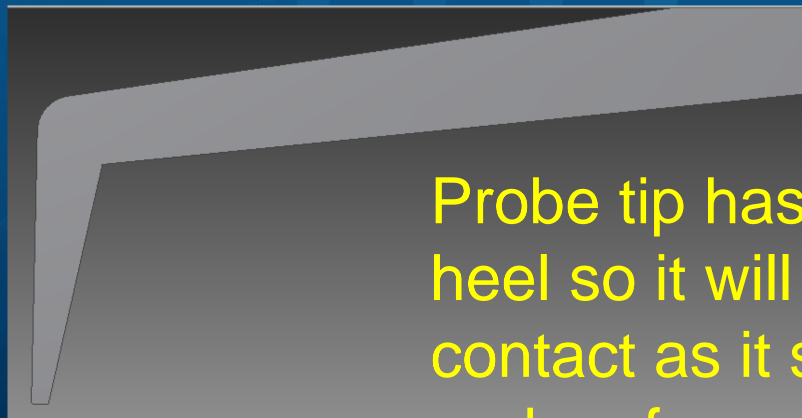


# Probe Model Used in These Simulations



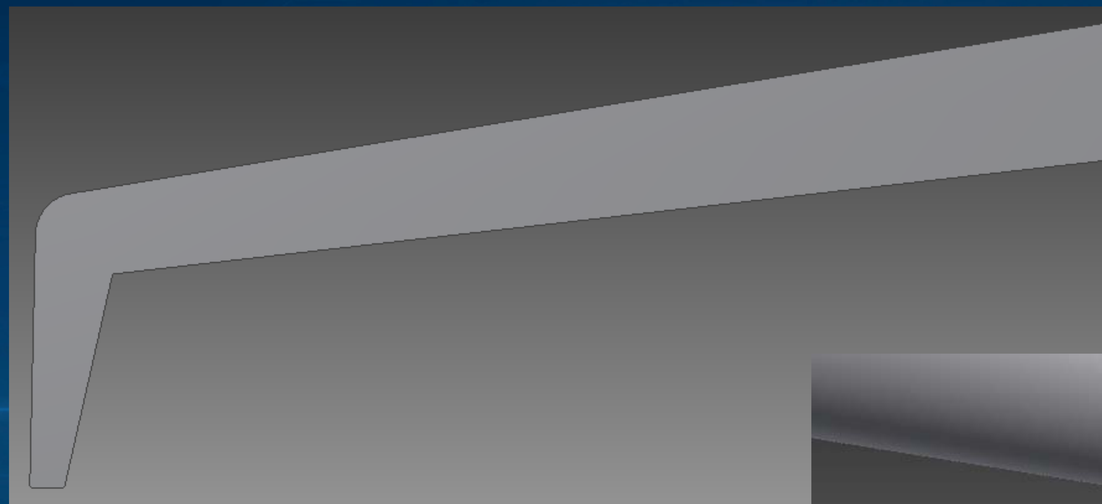


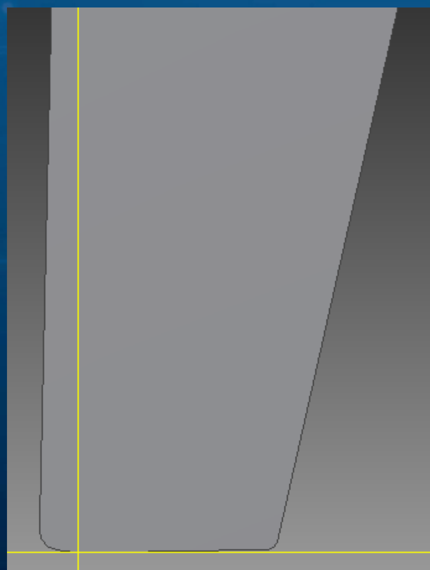
Material properties of W are used for the probe

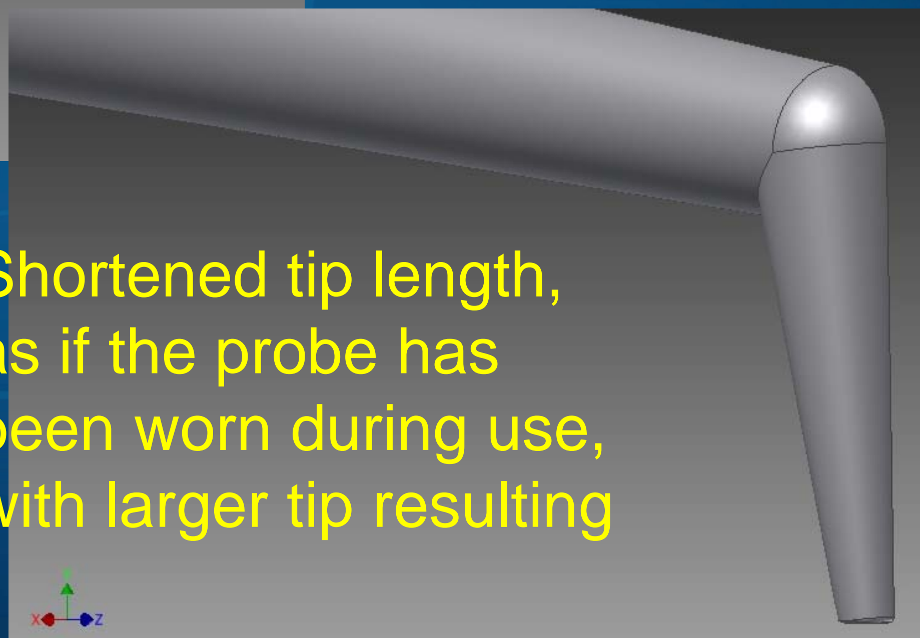


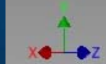
Probe tip has a slight relief on the heel so it will continue to make contact as it slides forward on the pad surface

# Larger Tip Probe Model



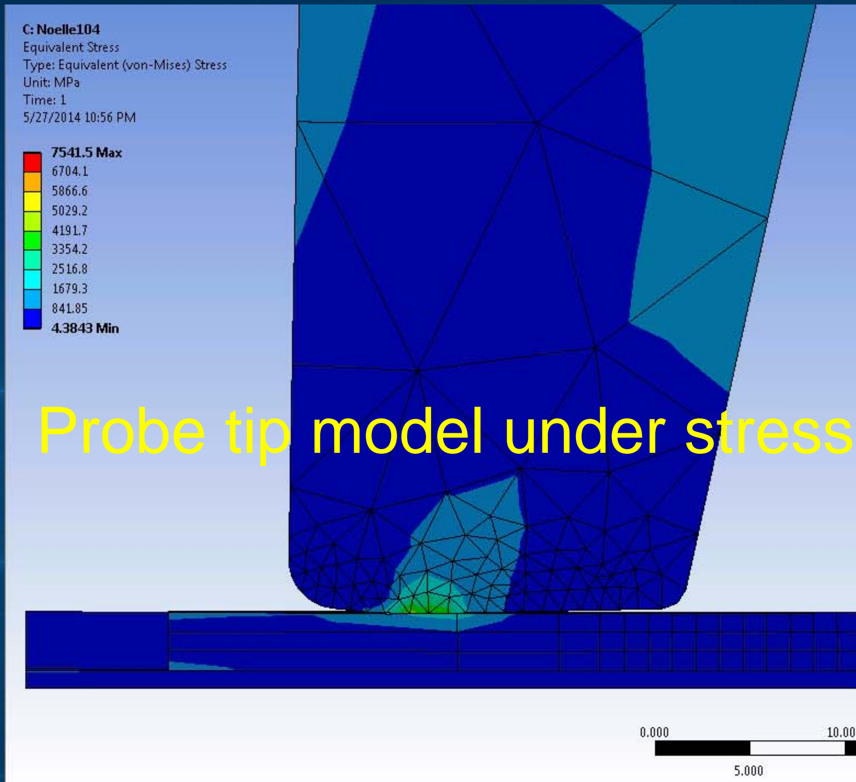


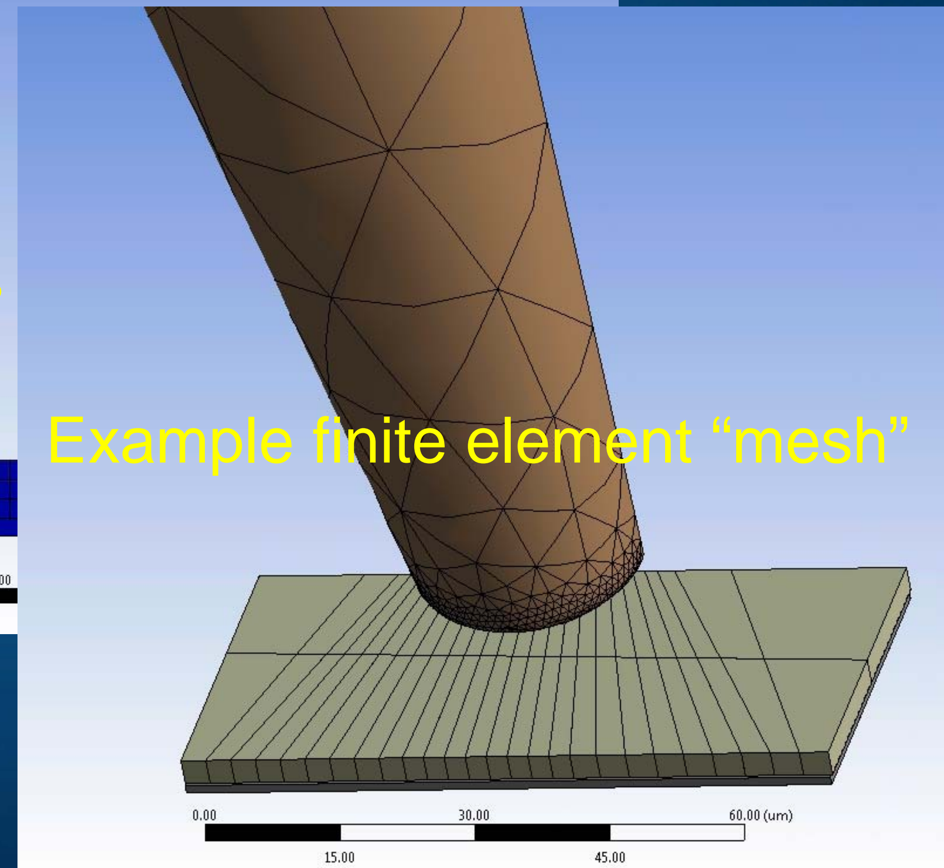


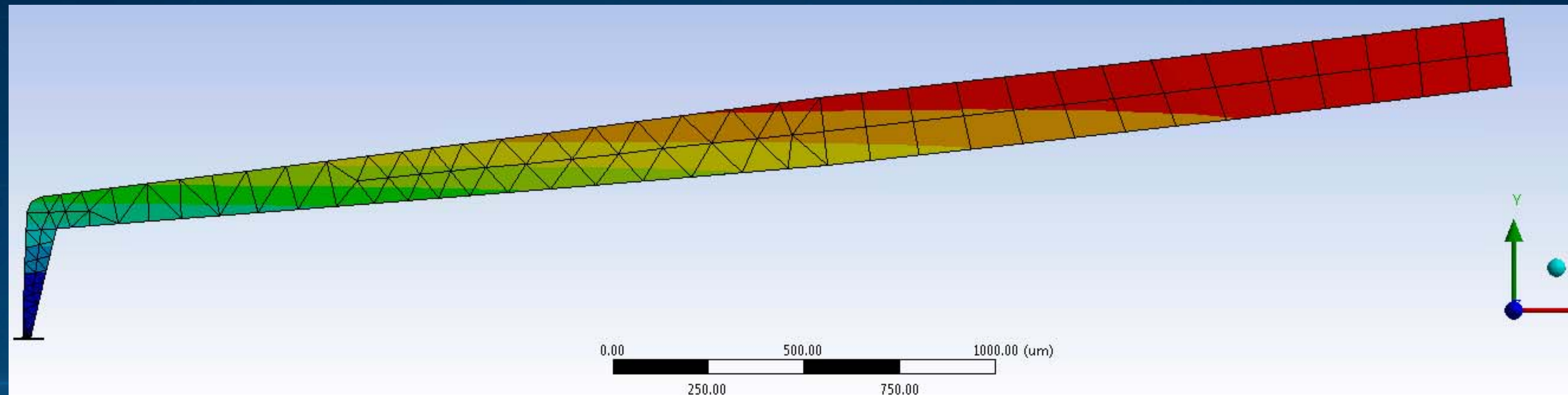
Shortened tip length, as if the probe has been worn during use, with larger tip resulting

# Cantilever Probe Model

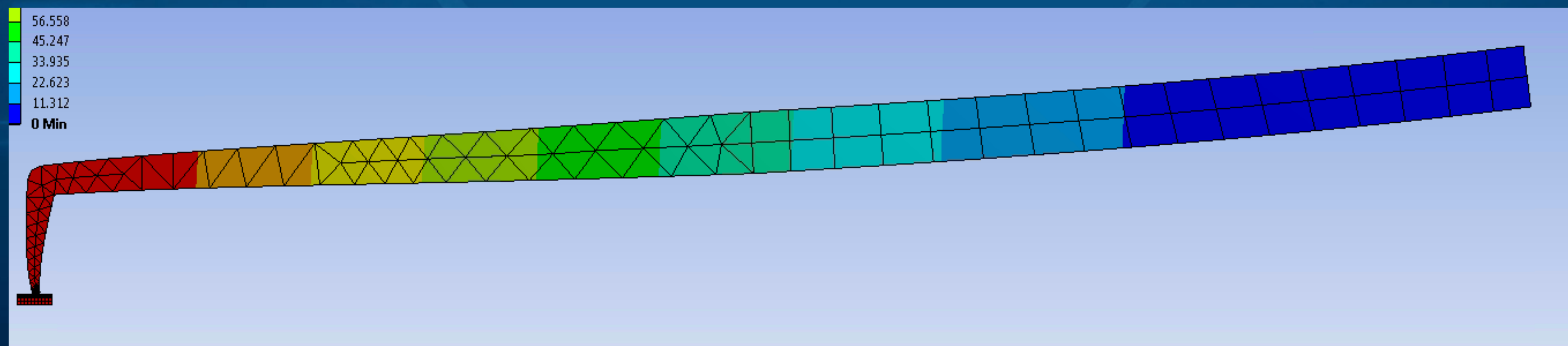


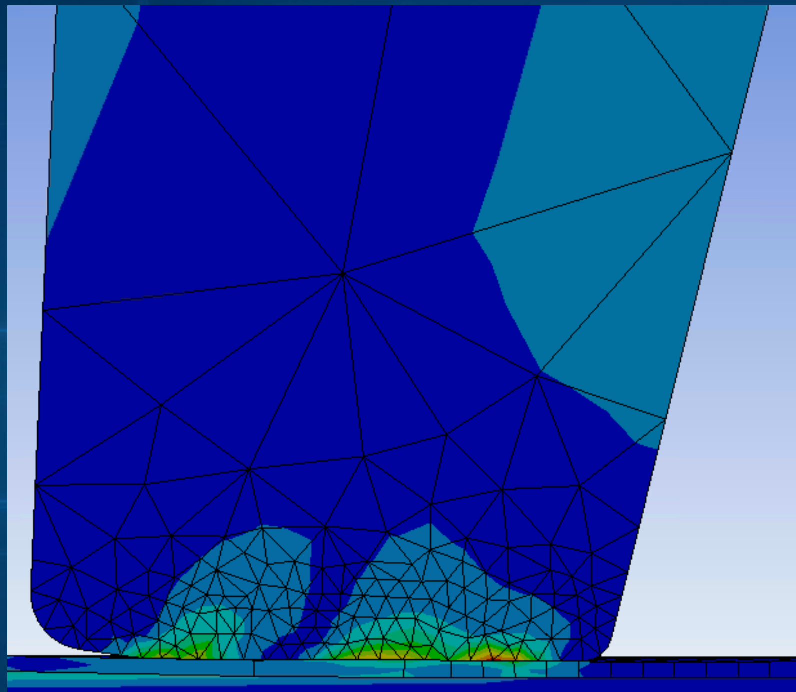
# Probe Tip Models Under Stress



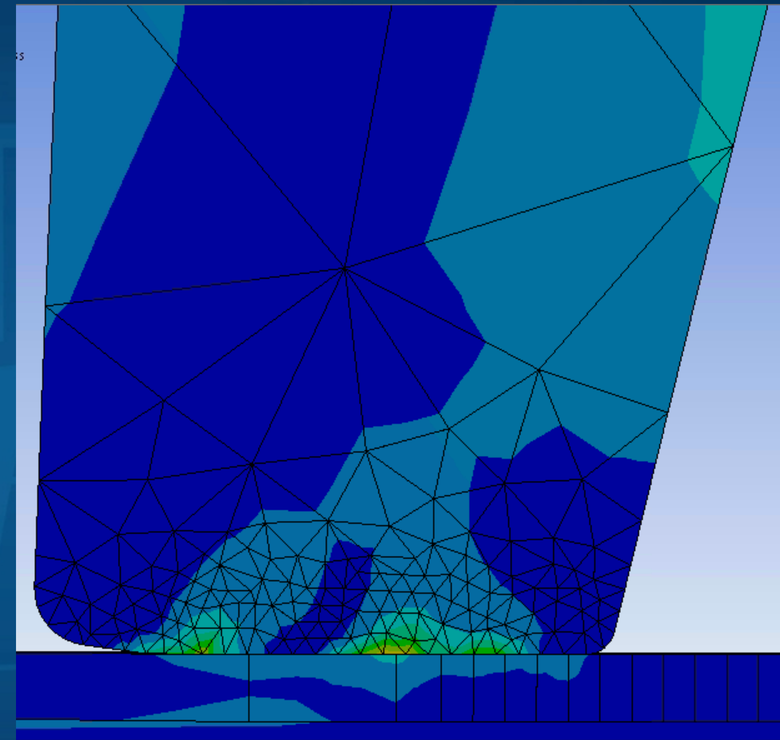

The bond pad's upwards movement strains the tip, with the shank as a spring



# Probe tips on Thin and Thick Pad Al

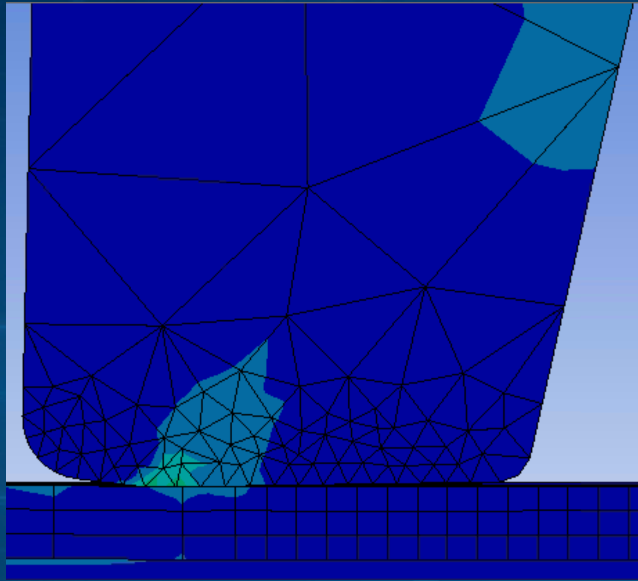


0.7um pad Al thickness

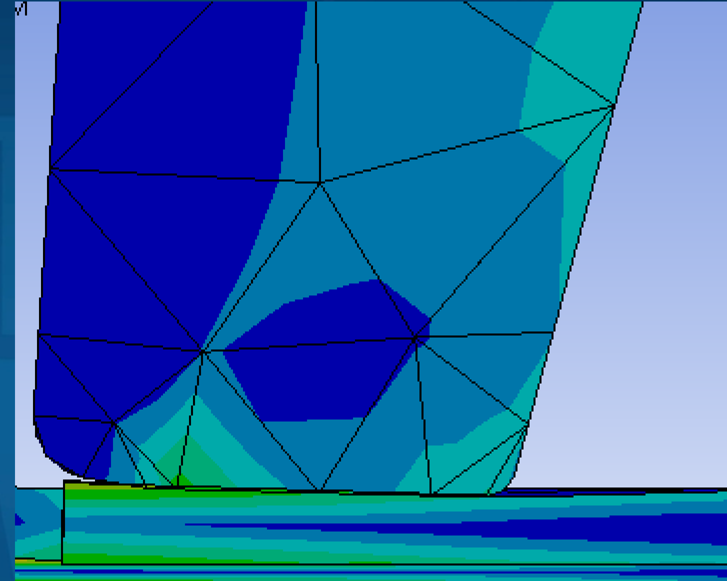


3.0um pad Al thickness

# High Force Probe Tip

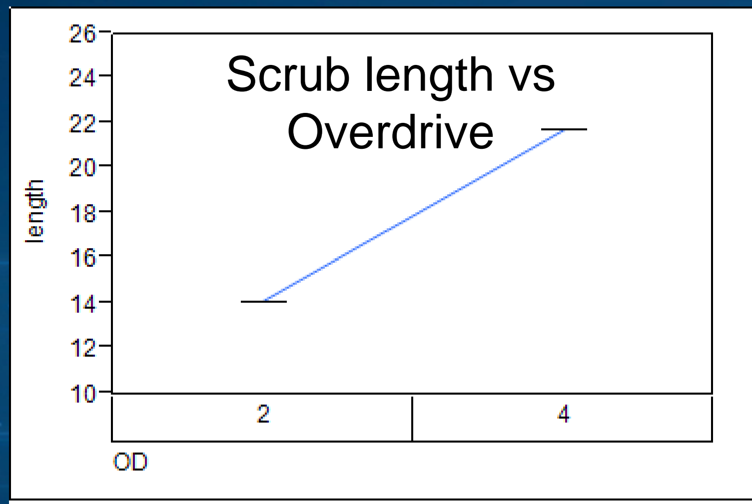


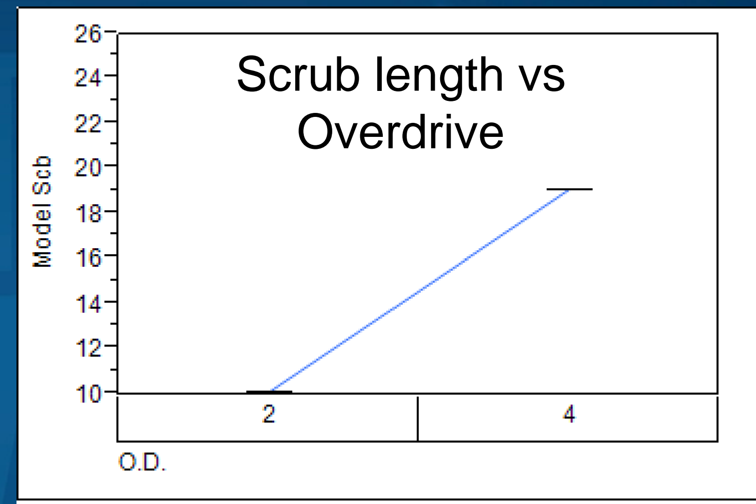
Low Overdrive



High Overdrive

# Overdrive Effect: Measure, Model

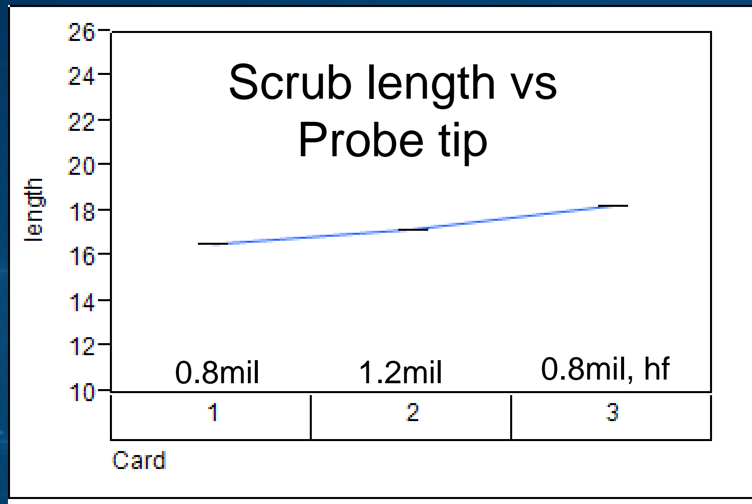


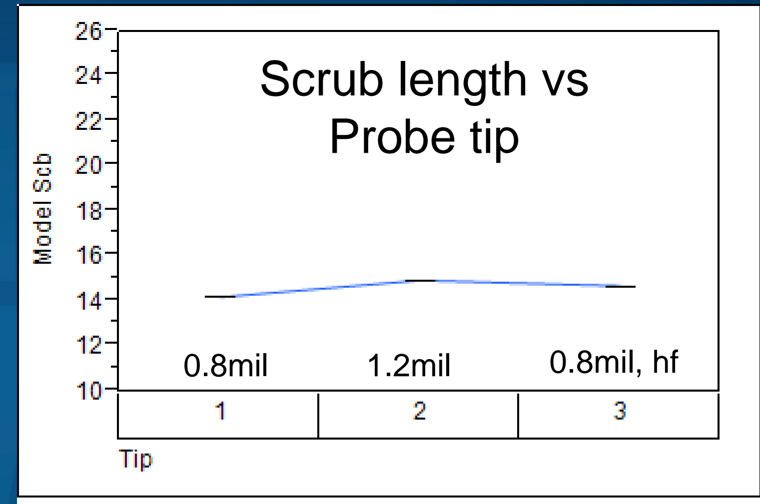

- **Overdrive is easiest to model and simulate**
- **Slope matches, but need offset adjustment in model**

# Probe Tip Effect: Measure, Model

Measured



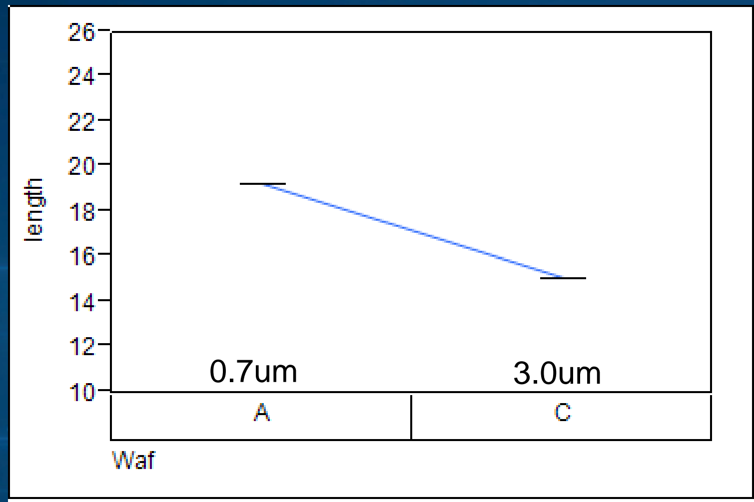

Simulated



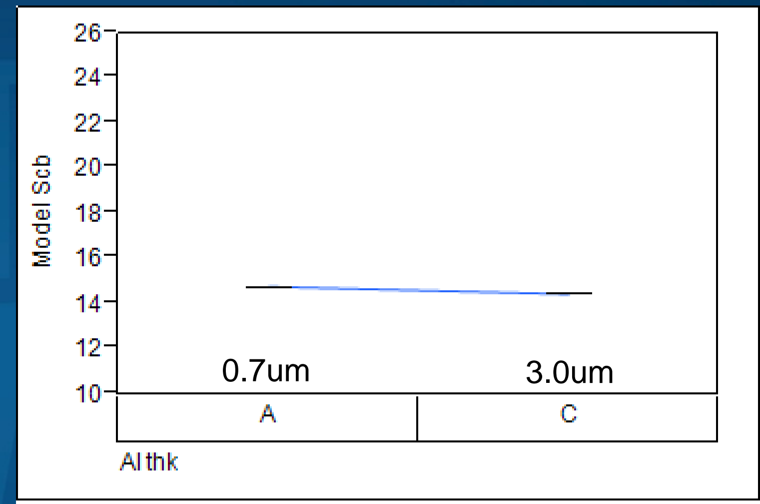

- **Model has small offset but matches slope for small and large tips**
- **Model is off for high force tip – insufficient force applied, compared to actual probes**

# Pad Al Thk Effect: Measure, Model

Measured

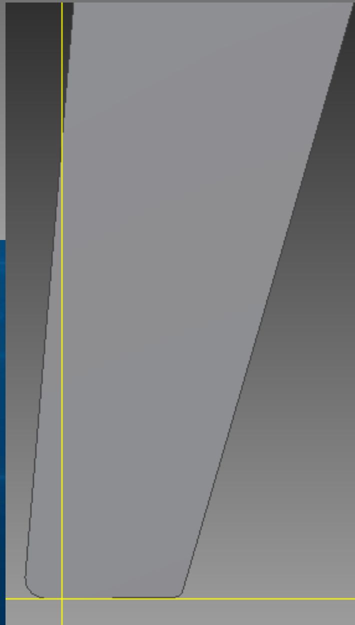


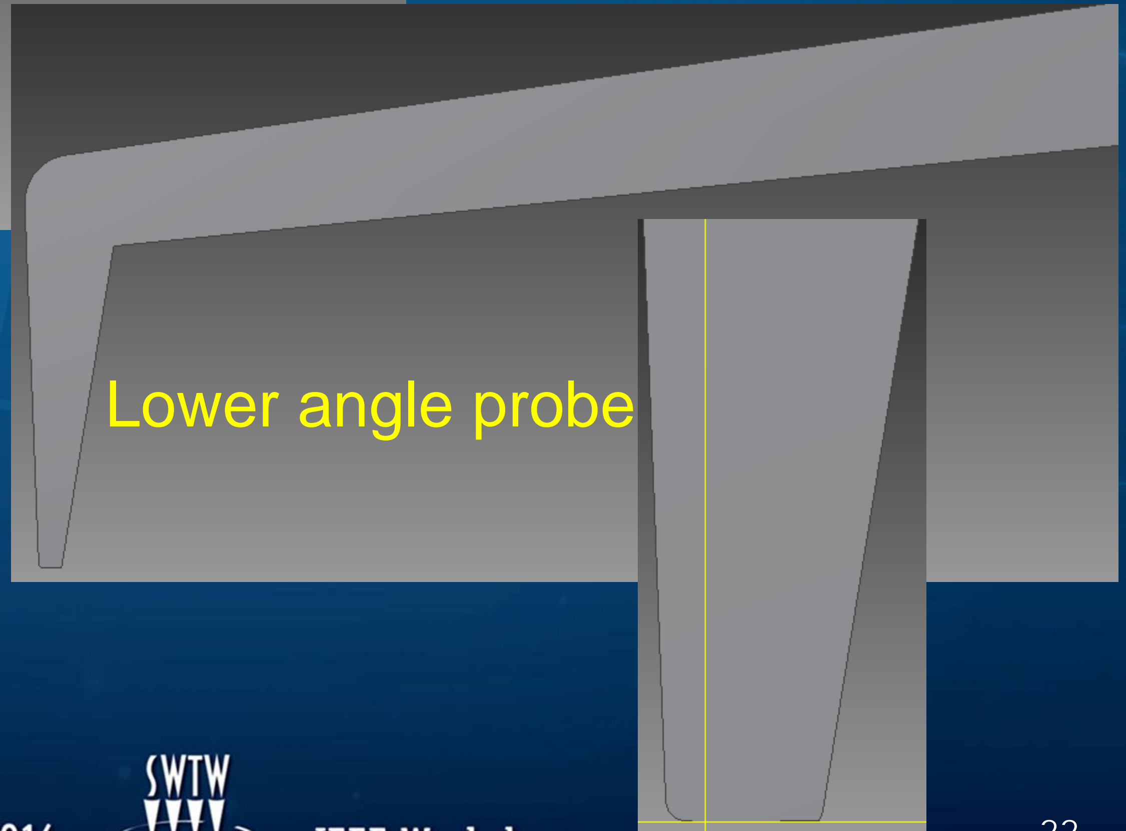

Simulated



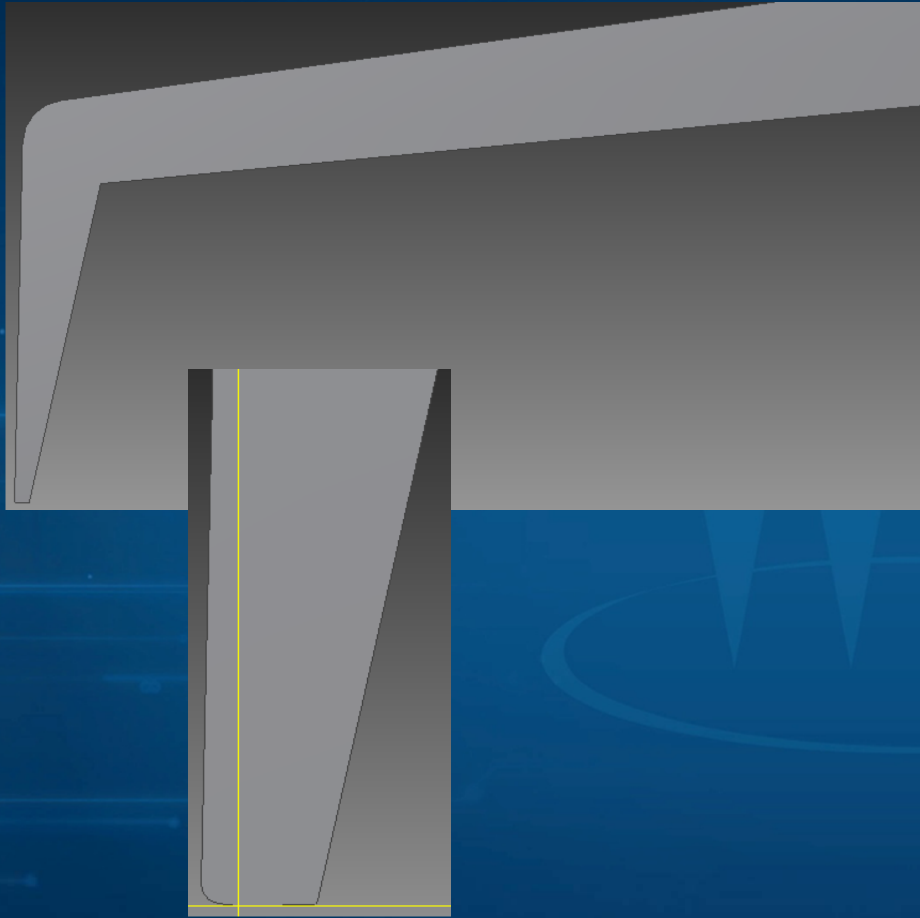

- **Insufficient interaction with the pad Al in the model, so the scrub length doesn't drop enough**
- ***Recommend more tip contact area in the model***

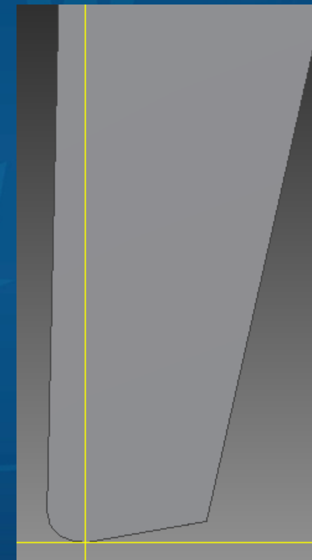
# Other Probe Models

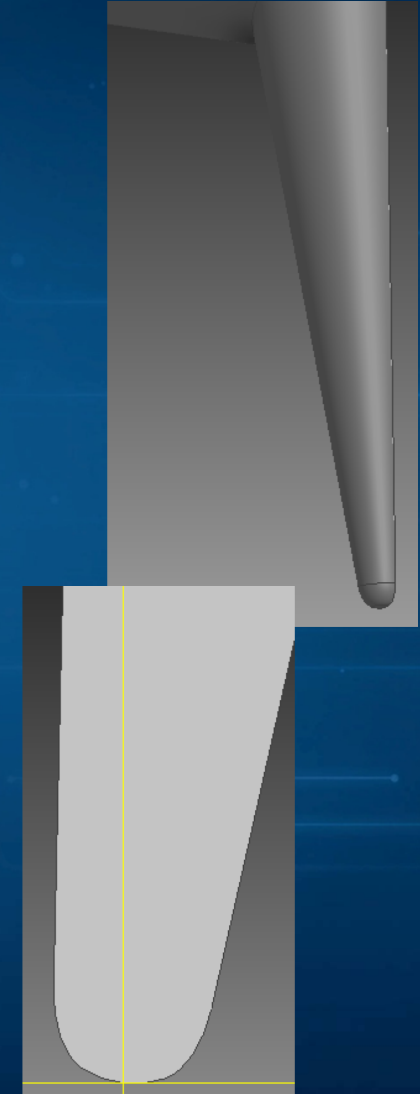




# Other Probe Models (cont)







# Summary

- Experiment to create various probe marks
  - 3 pad Al thicknesses
  - 3 different probe tip conditions
  - 2 different overdrives
  - 1 and 2 touches
- Created FEM models of various probe tips
- Ran simulations to attempt matching with experiment data
- Lots more work to do…