
IEEE SW Test Workshop
Semiconductor Wafer Test Workshop
June 9 - 12, 2013 | San Diego, California

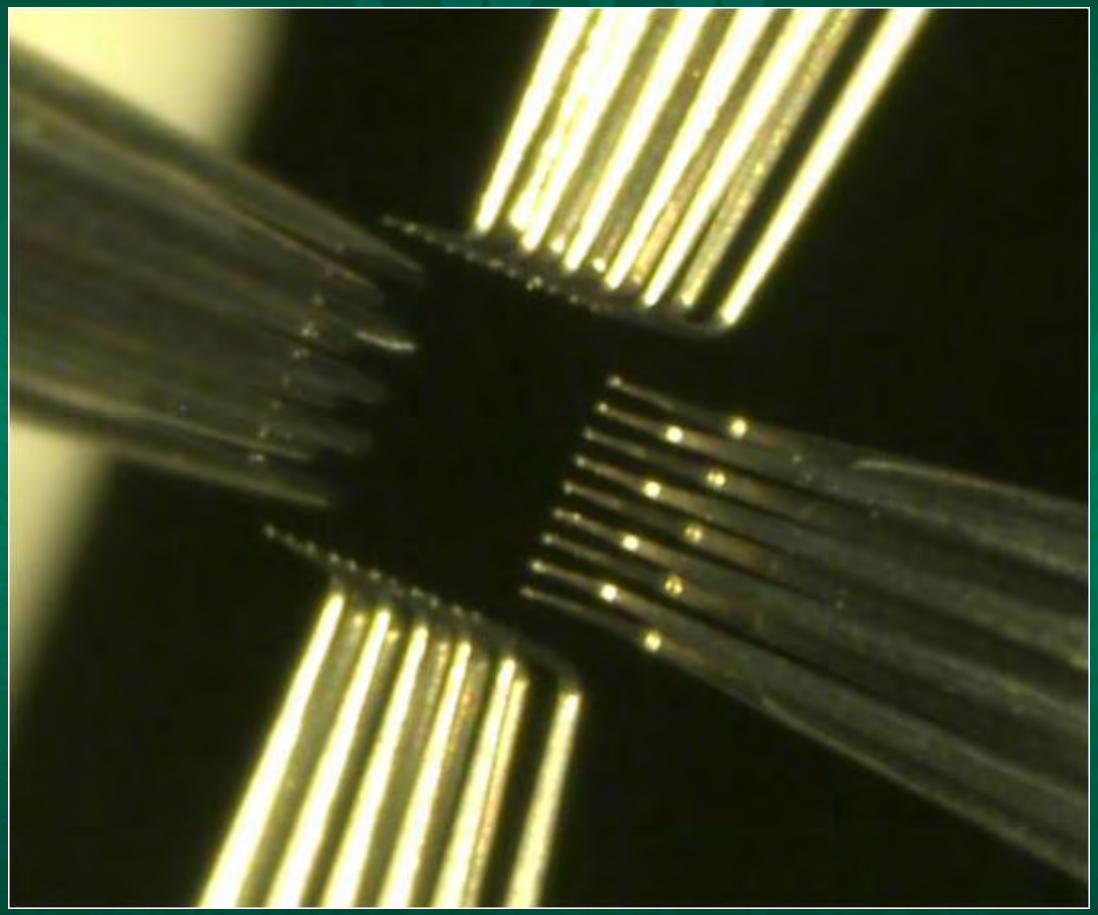
# Study of Cantilever Probes and Probe Marks




Stevan Hunter *PhD*[1,2], Clint Churchill[1], Vail McBride[1], Tiago Rodrigues[3], Shashi Sharma[3], Prakash Subedi[3], Ruben Torres[1,2], Dustin Whittaker[3]

[1]ON Semiconductor,[2]Idaho State University,
[3]Brigham Young University Idaho

# Example Cantilever Probe Tips

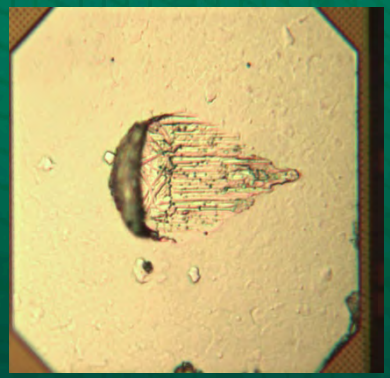


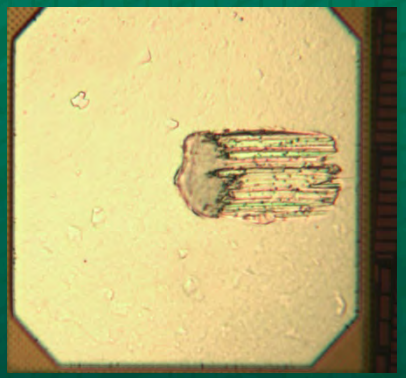
# Background

- **ASICs often require multiple probings**
- **Driven to lower cost while increasing reliability**
  - ❑Pad structure mechanical robustness was improved
    - – Thin pad Al
    - – Circuit Under Pad on Al-$SiO_2$ CMOS technologies
    - – Cu wire (instead of Au), ball bond or wedge bond
    - – Shrinking pad size
- **Desire to continue to use inexpensive cantilever probe cards…**

# Probe Mark Examples

- Probe marks can have many different characteristics
- The marks below are from different probe tips, all at 4mils overdrive



# Objectives

- **Discover the best methods for using cantilever probe cards in volume ASIC production**
  - Bond pads are fragile (don't crack them)
  - Probe marks interfere with wirebond reliability
  - Robust tip performance and long lifetime desired

➢ **Probe mark requirements are tightening:**

- ➢ small size
- ➢ well positioned
- ➢ non-invasive

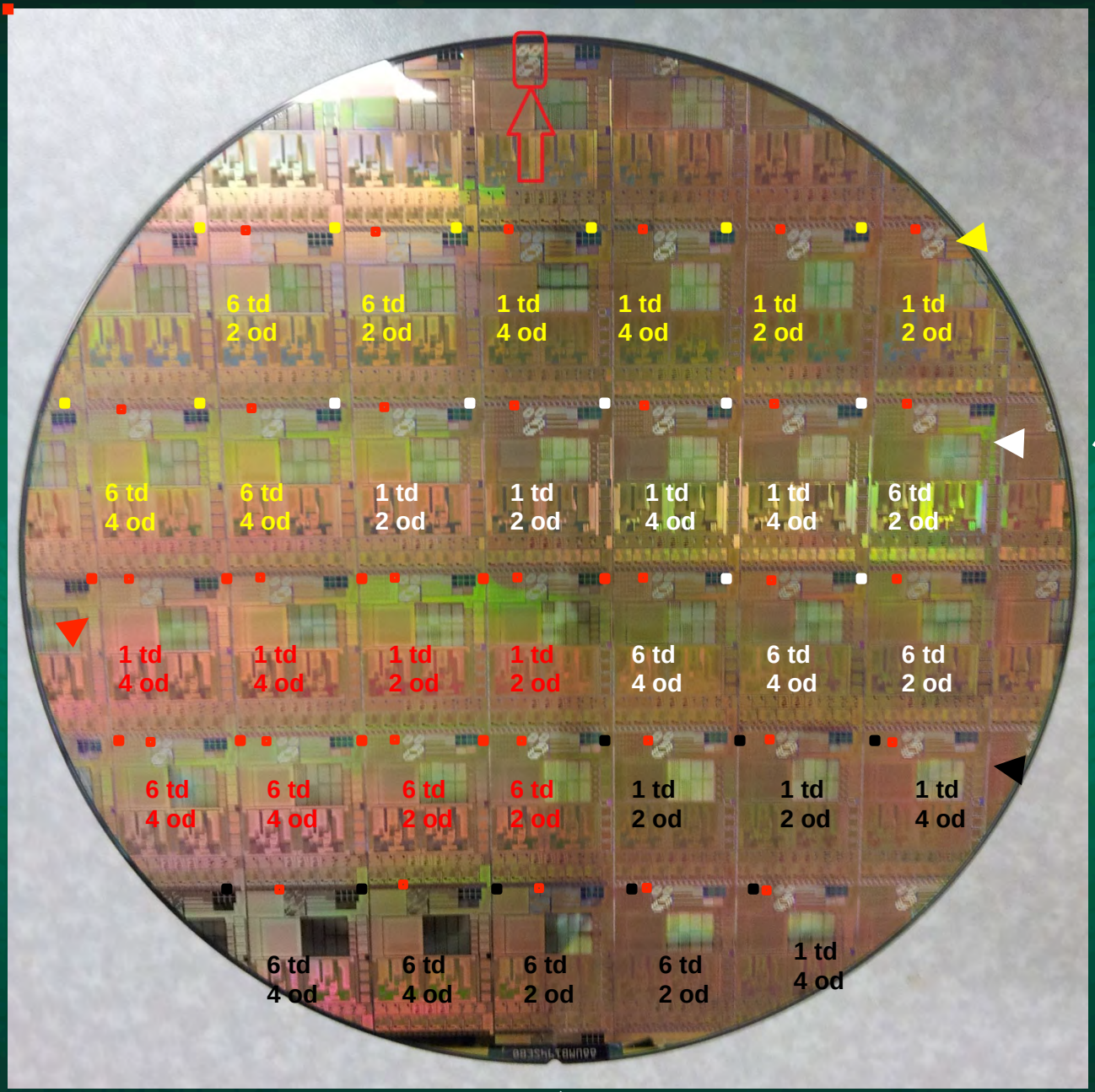
# Experimental

- **4 probe cards with W-Rh3% cantilever tips**
  - Four different probe cards, 40 tips, 2 tip lengths
  - 0.8mil, 1.0mil, 1.2mil tip diameters
  - 90°, 95°, 104° tip angles
- **1 touchdown, 2 or 4mils overdrive**
- **16 different bond pad structures**
- **32 die probed in each treatment**
  - 40 pads per die

➢ **Probe marks analyzed for length, width, area**

# Cantilever Probe Cards Detail

| Card Name | Tip Force | Tip Lengths | Tip Angle | Tip Diameter | # Die | 2mil od | 4mil od |
|---|---|---|---|---|---|---|---|
| A | High | Short, Long | 104° | 1mil | 4 | x | x |
| B | High | Short, Long | 104° | 0.8mil | 4 | x | x |
| C | High | Short, Long | 100° | 1mil | 4 | x | x |
| D | Med | Short, Long | 90°, 95°, 104° | 0.8, 1.0, 1.2mil | 4 | x | x |



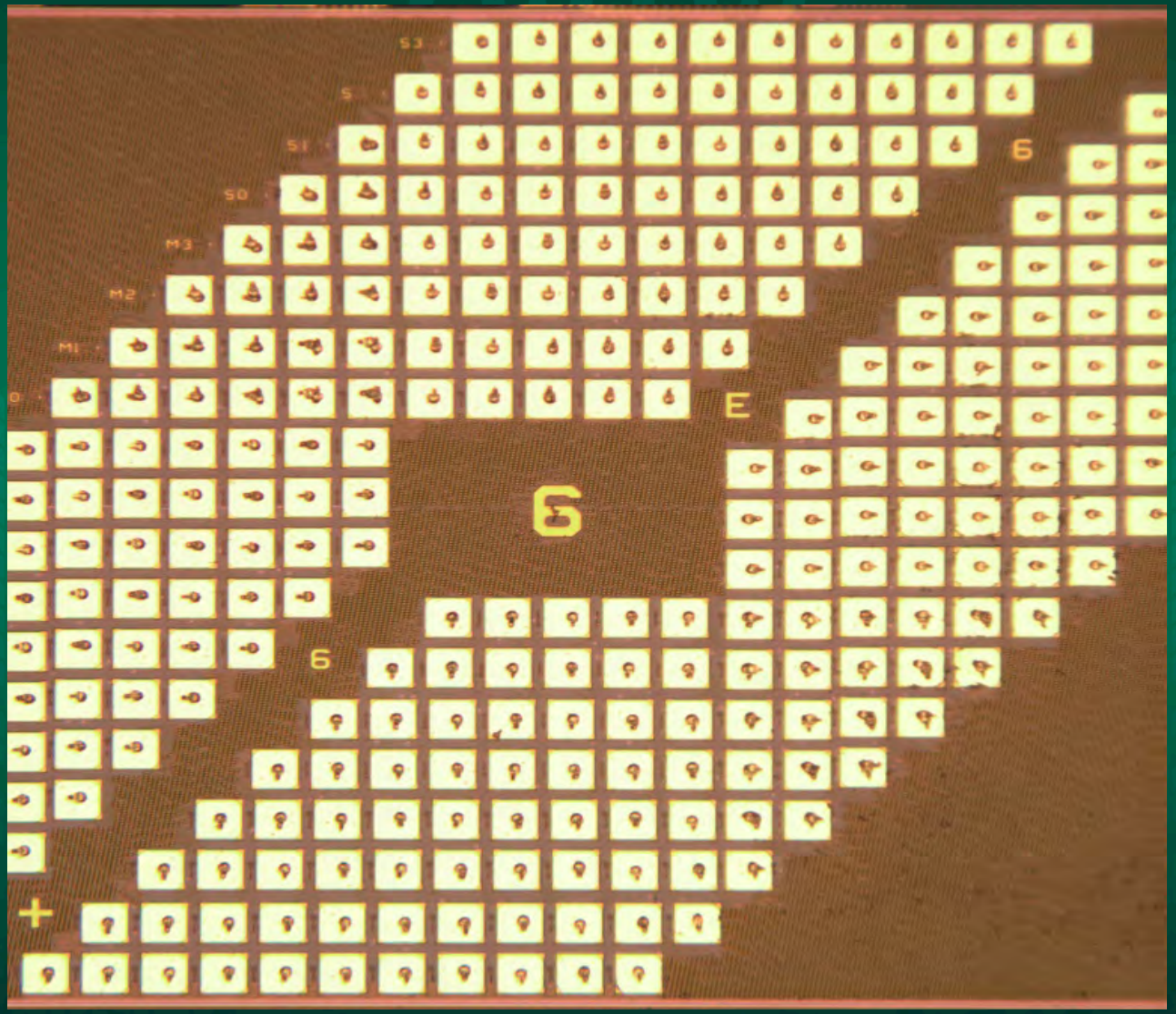

Probe Card "A"

Probe Card "D"

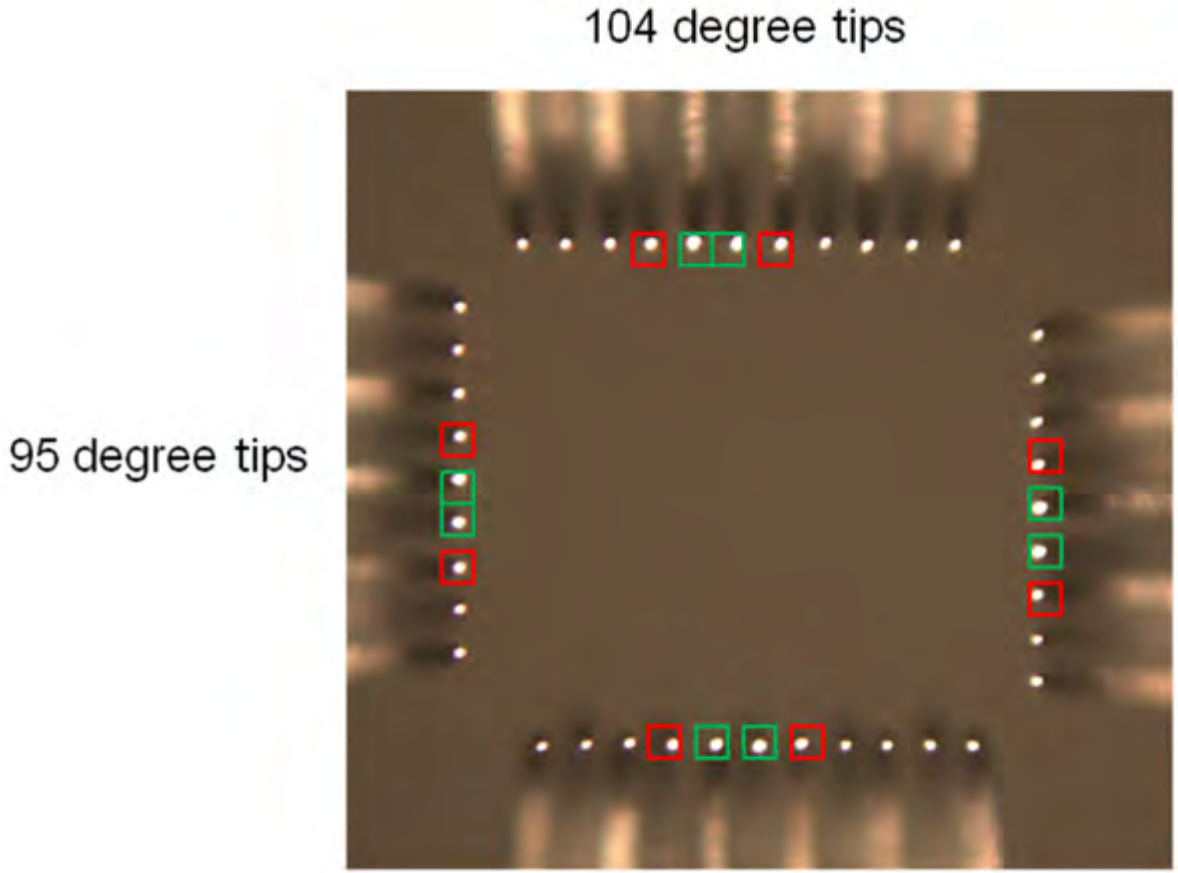
Probe Card "B"

Probe Card "C"

# Bond Pads Test Array Example

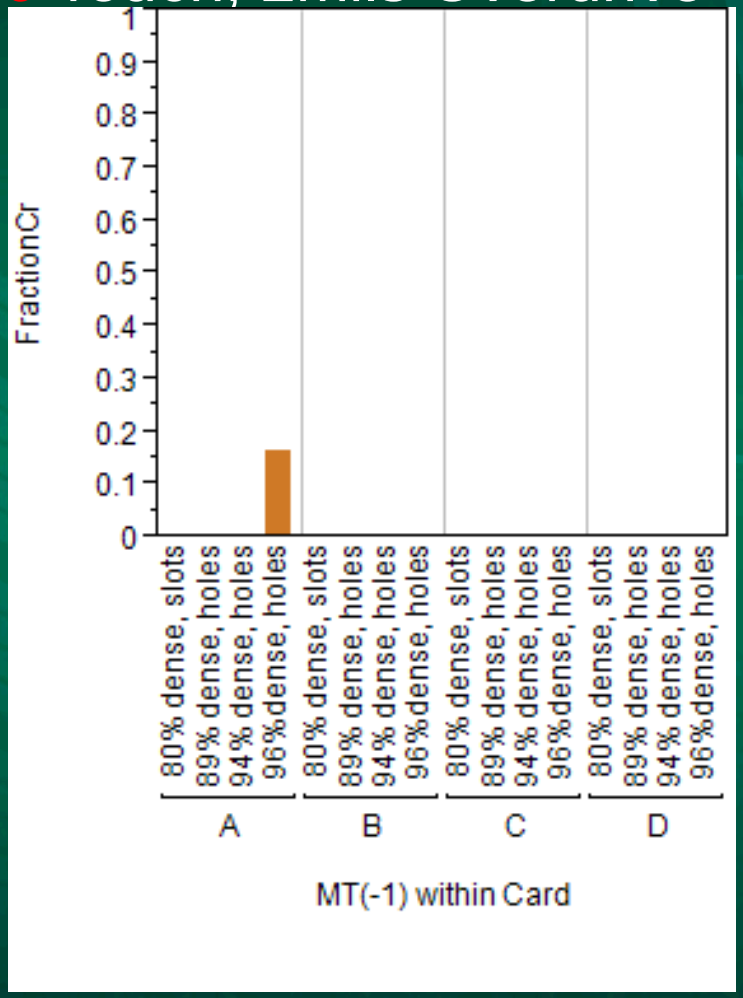


# Probe Card "D"

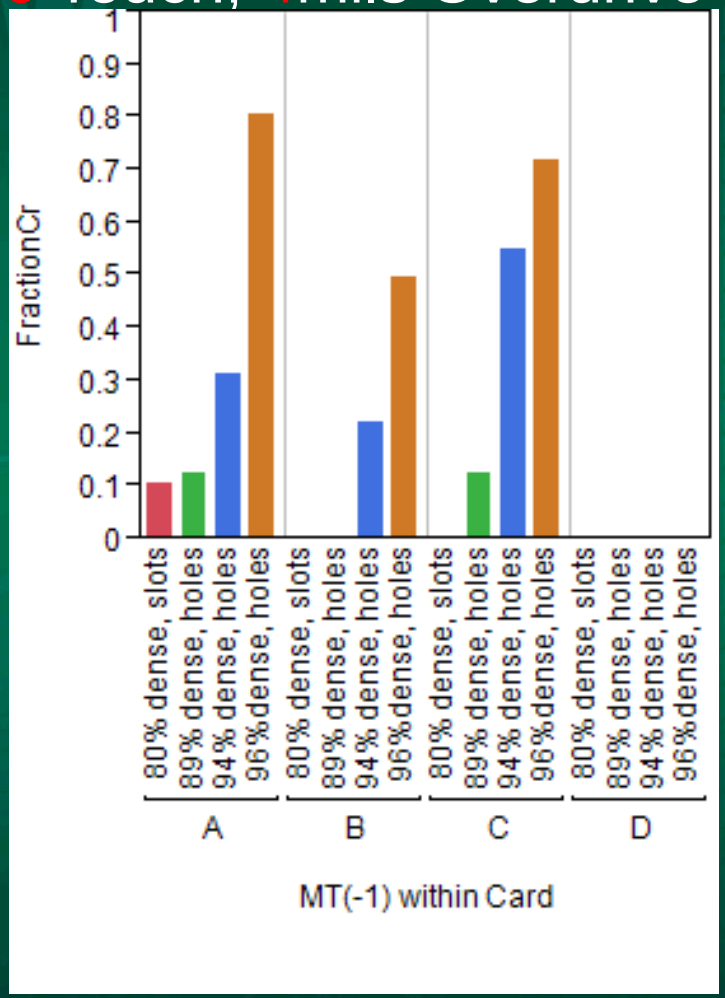


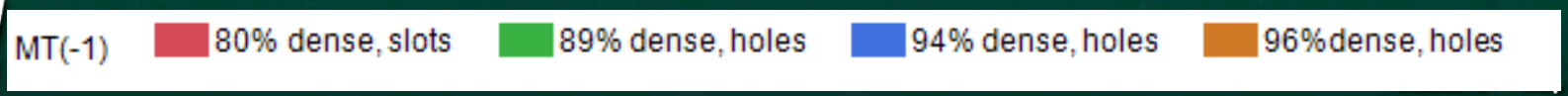
# Fraction Cracked (4 Probe Cards)

6 Touch, 2mils Overdrive




6 Touch, 4mils Overdrive

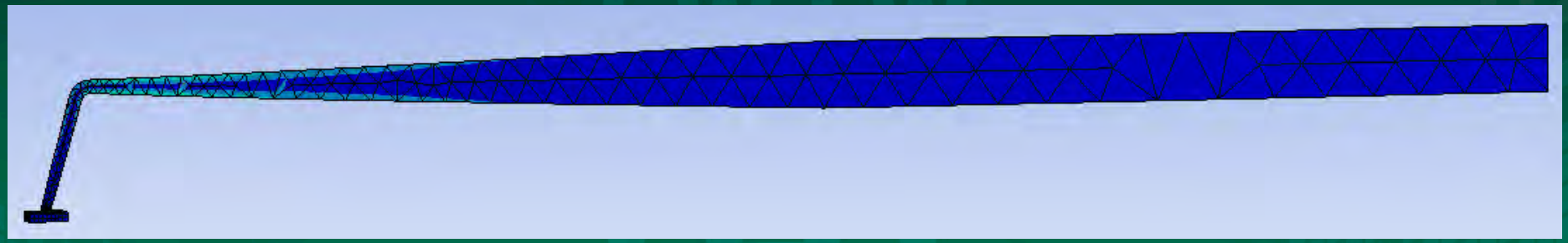


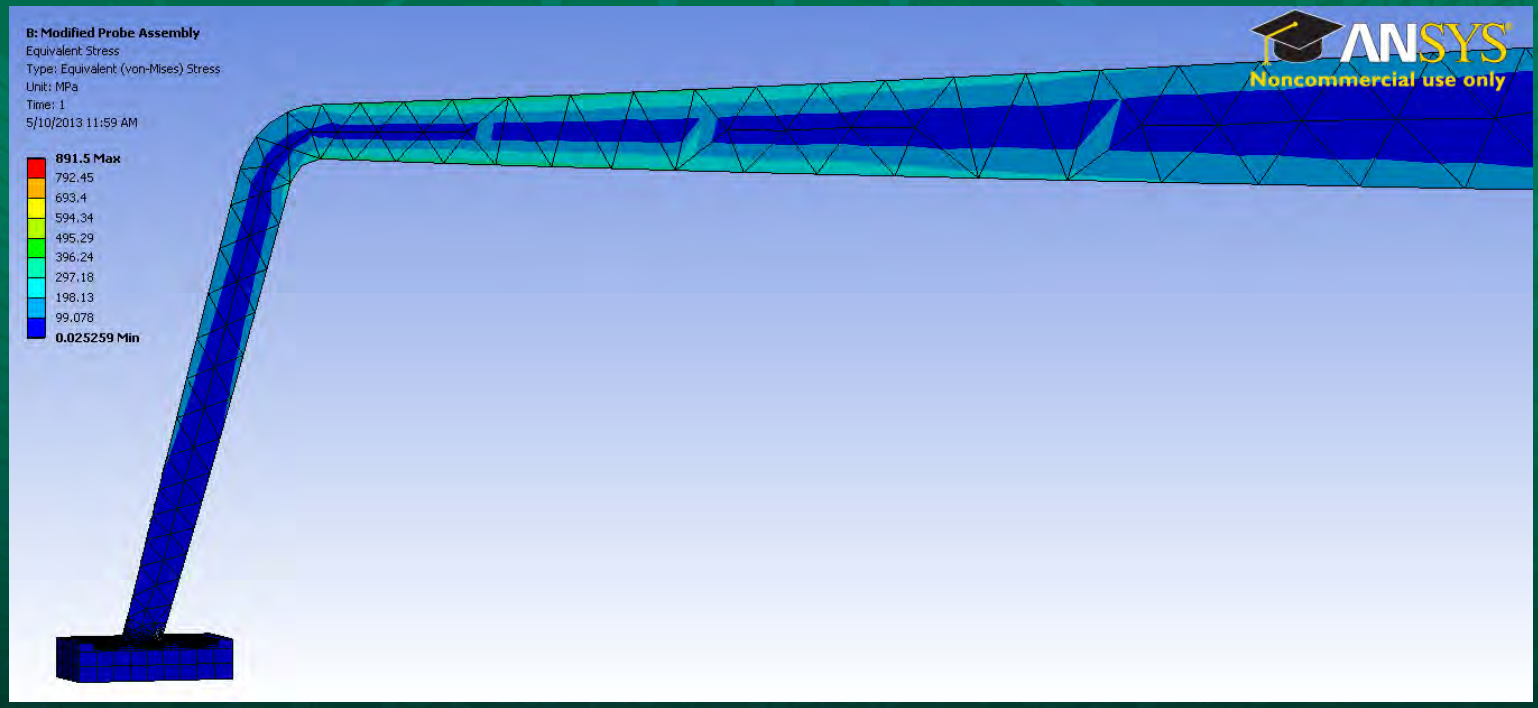



# Conclusions for Pad Cracking

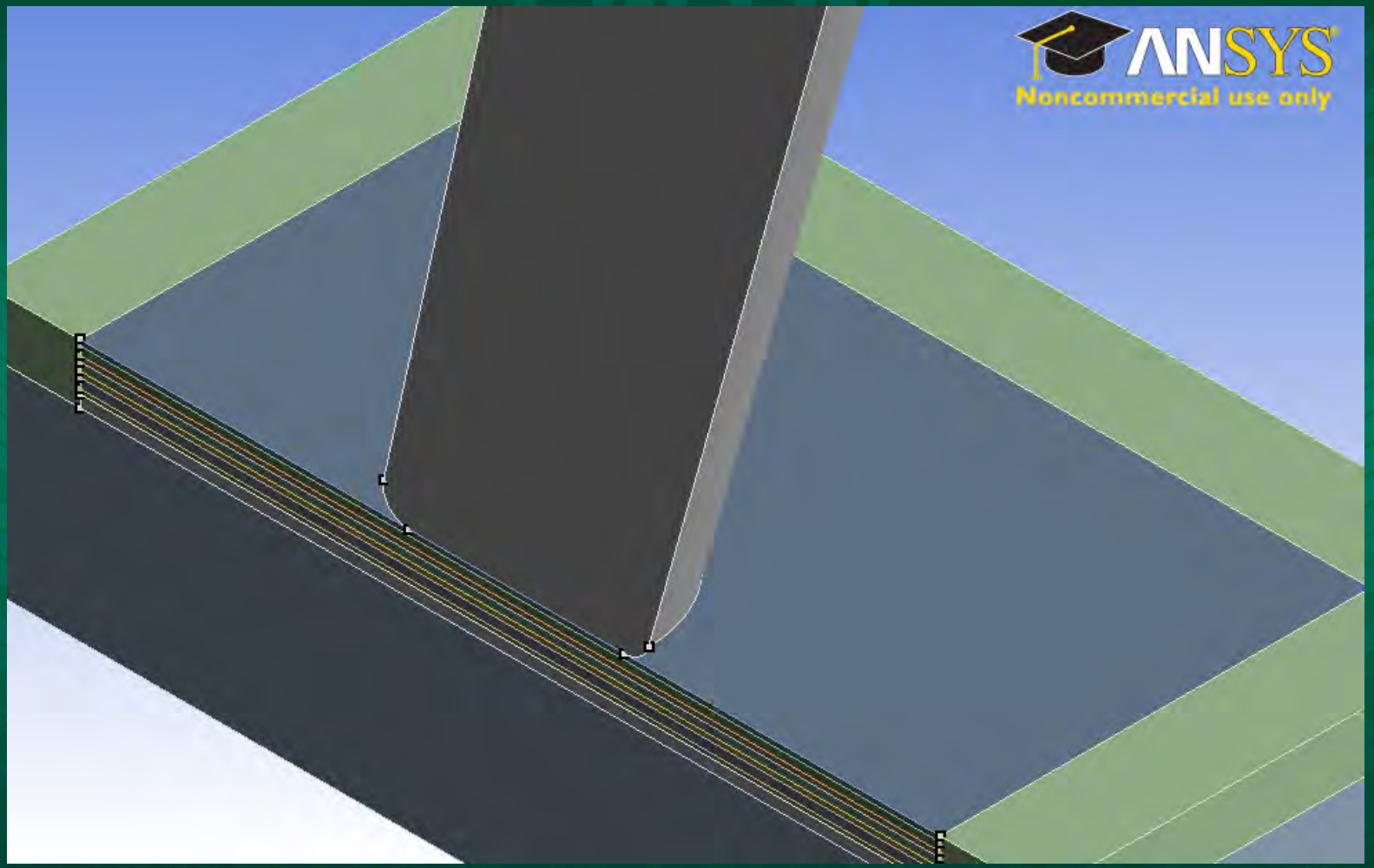
- High Force cantilever probe tips on certain bond pad structures cause cracking
- Cracking increases with overdrive, and high number of touchdowns makes it worse
- Avoid cracking by designing mechanically robust bond pads

# Cantilever Probe Model

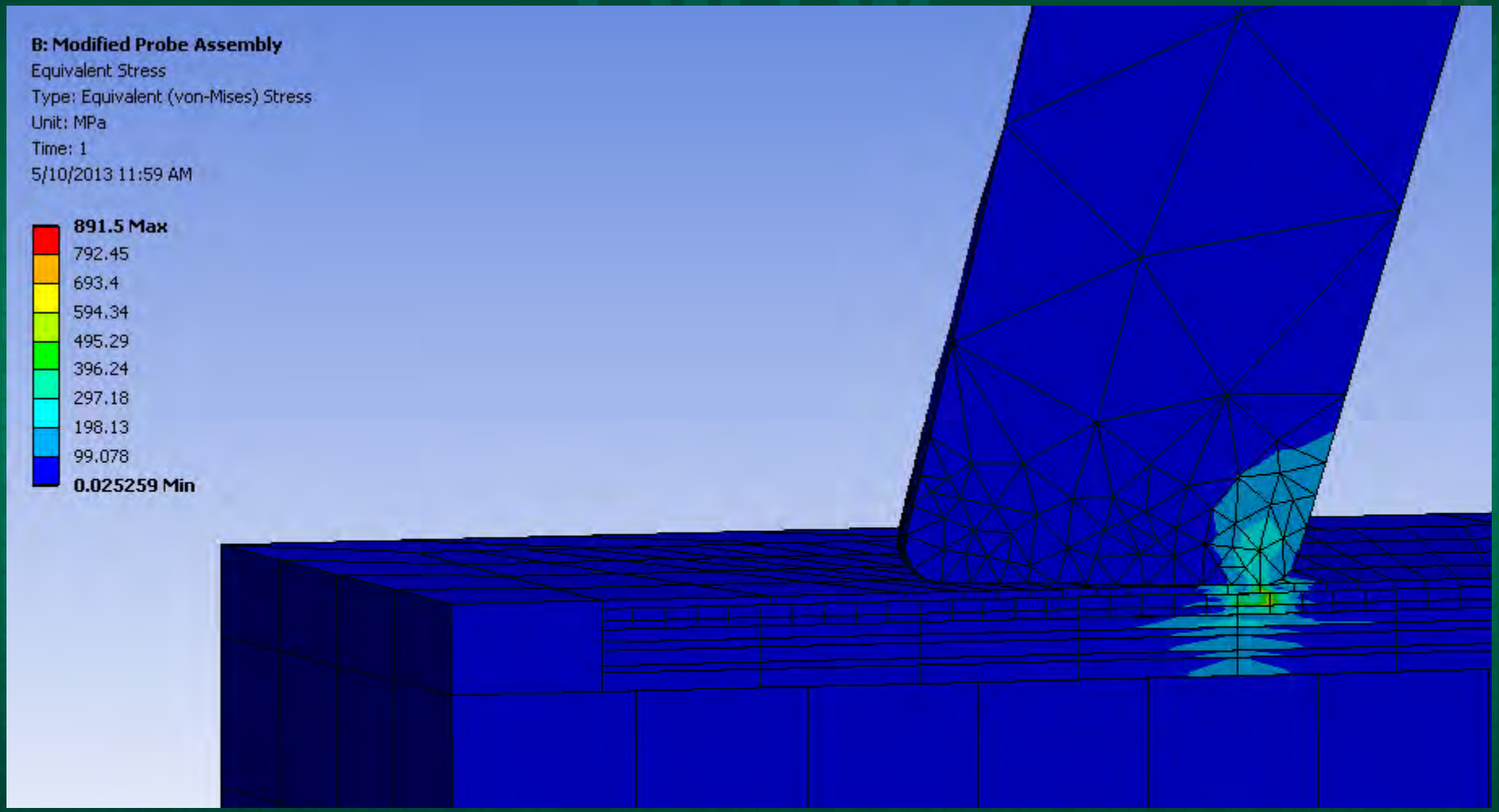




# BYU-Idaho Students: FEM Probing Model

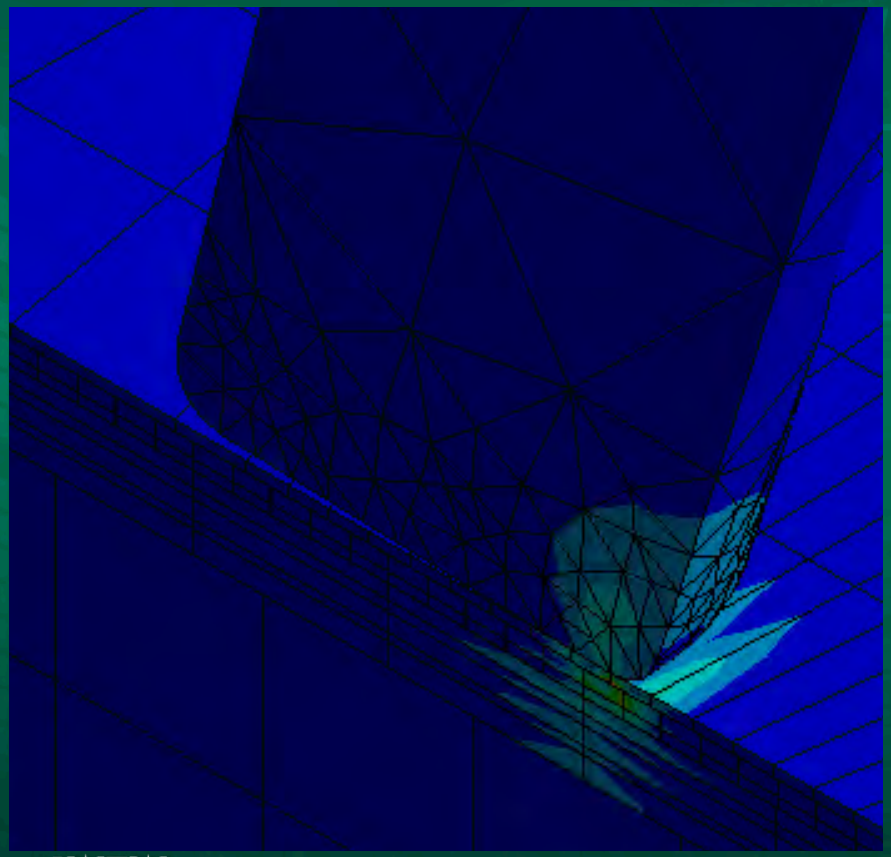


# Probe and Bond Pad Stress Detail

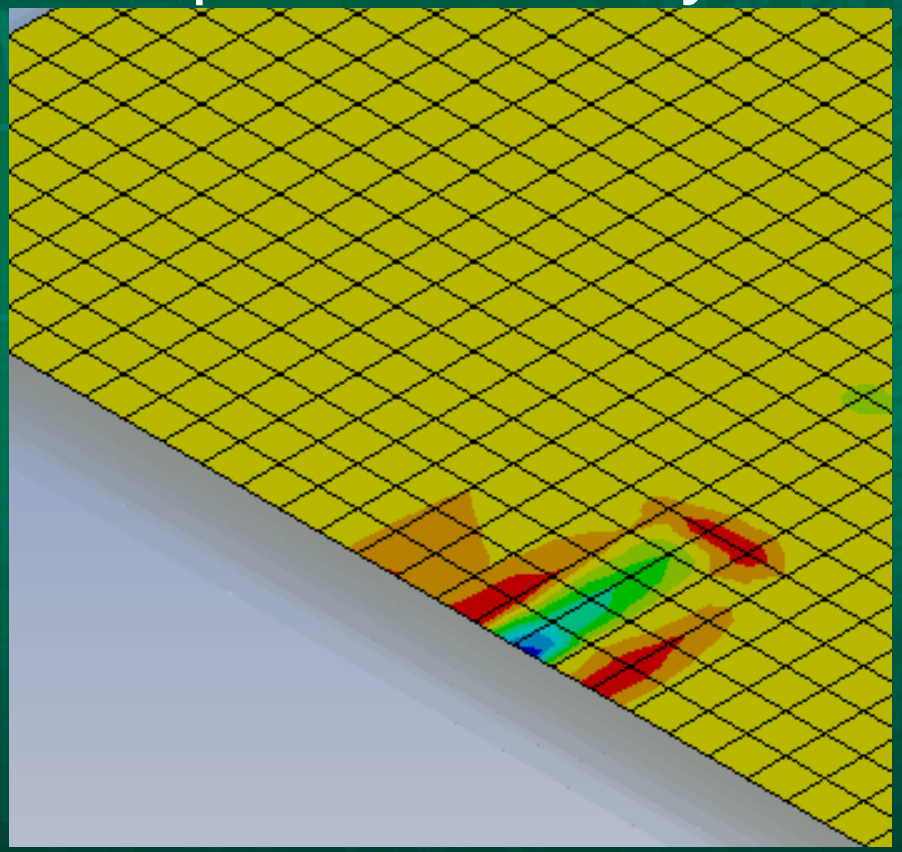


# Basic Stress Analysis

Von Mises Stress in Bond Pad Structure

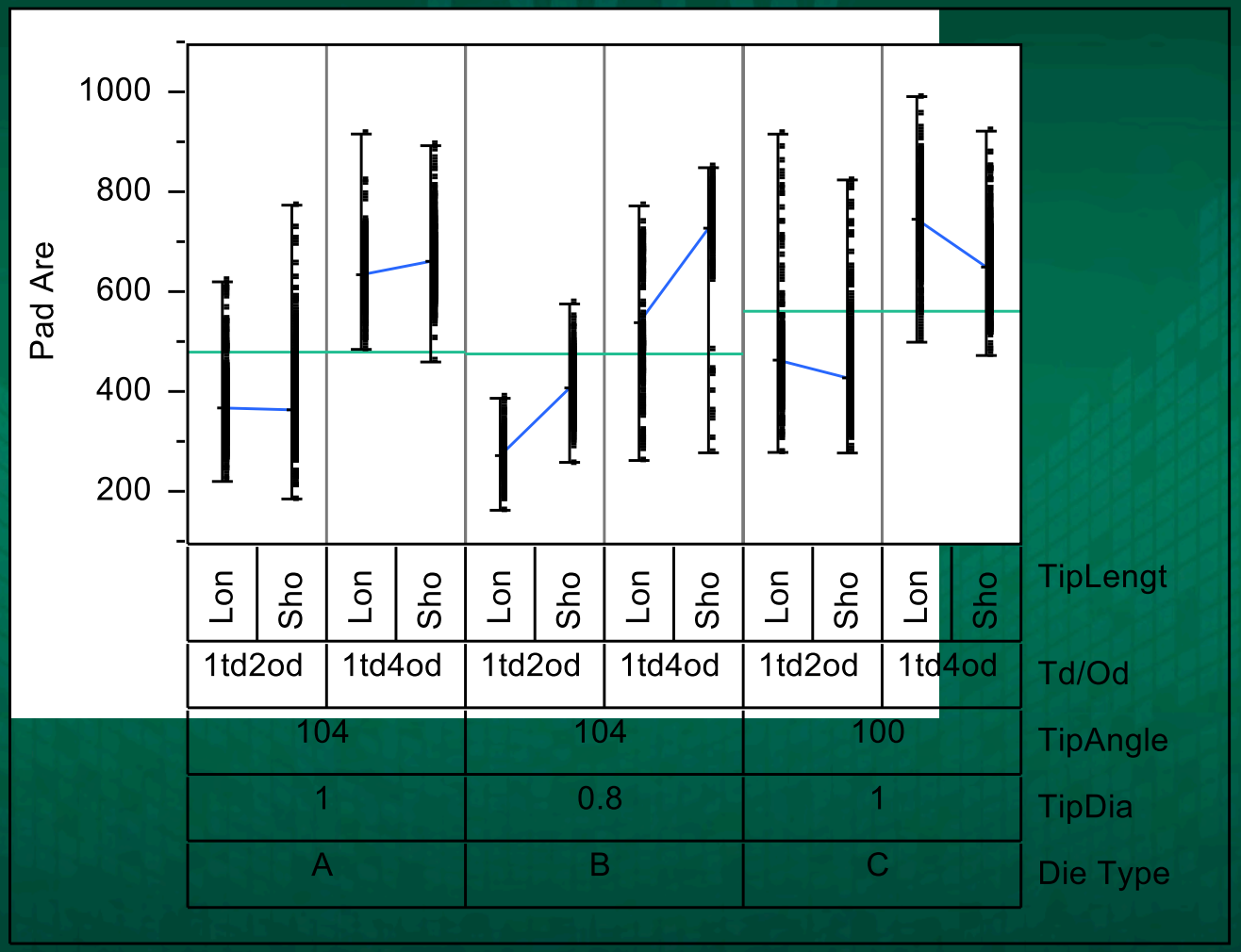


Max Principal Stress in Top IMD SiO2 Layer

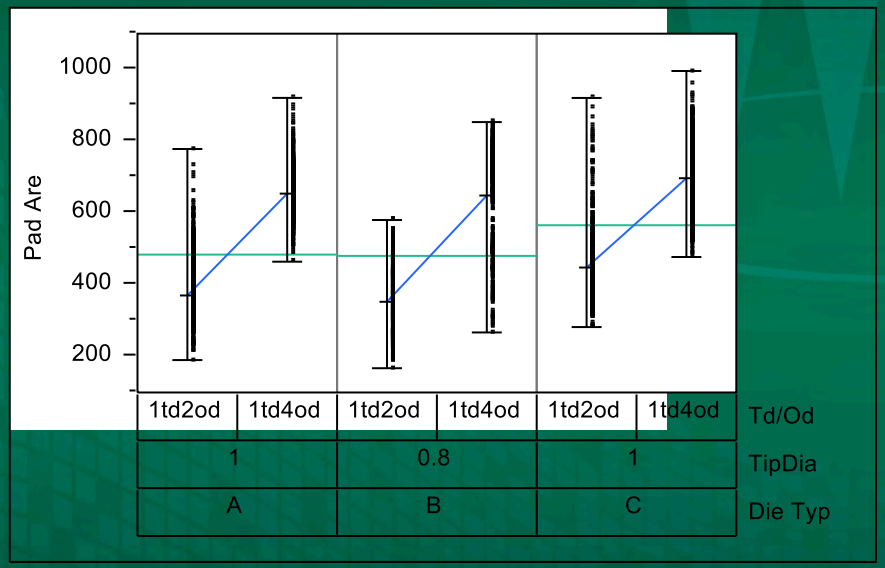


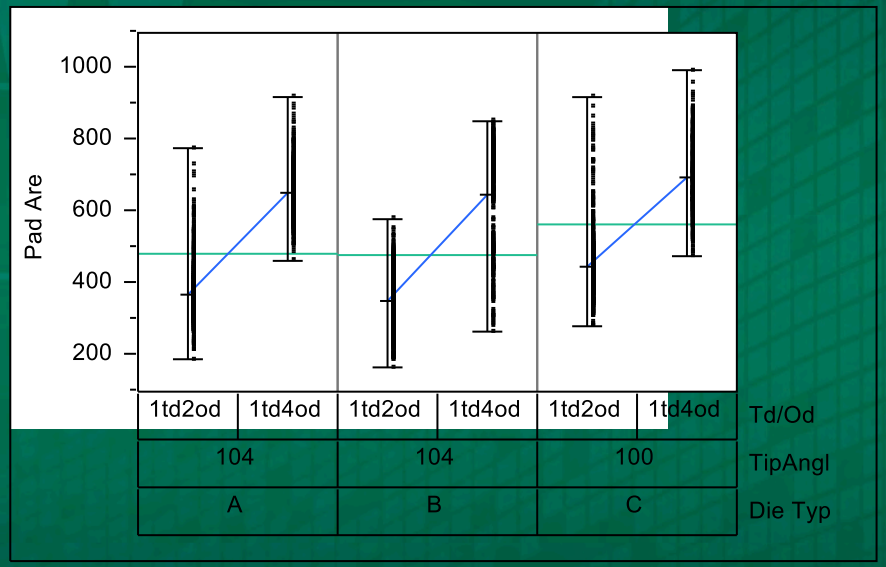
# Example Probe Marks

# Probe Mark Area: High Force Probe Tips

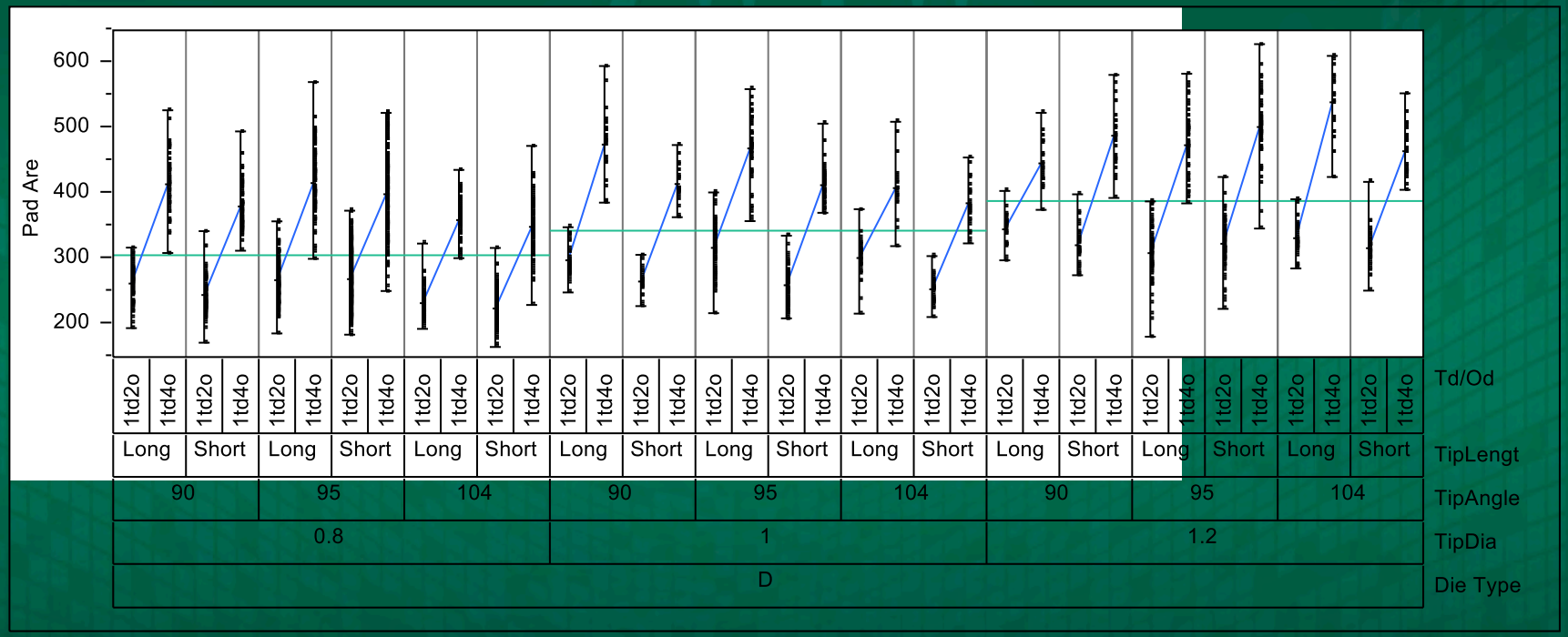


# High Force Probe Tips (cont)

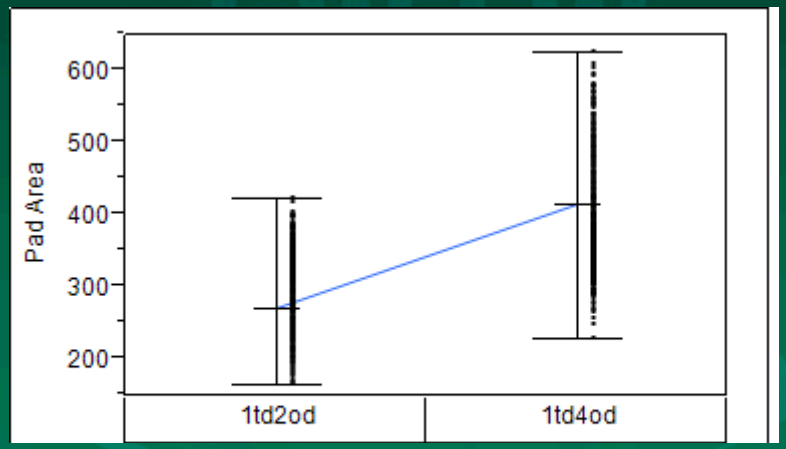


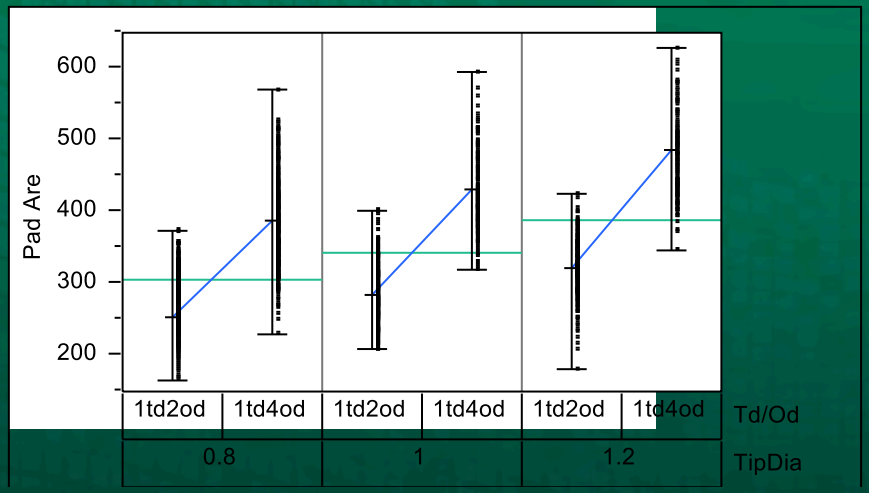



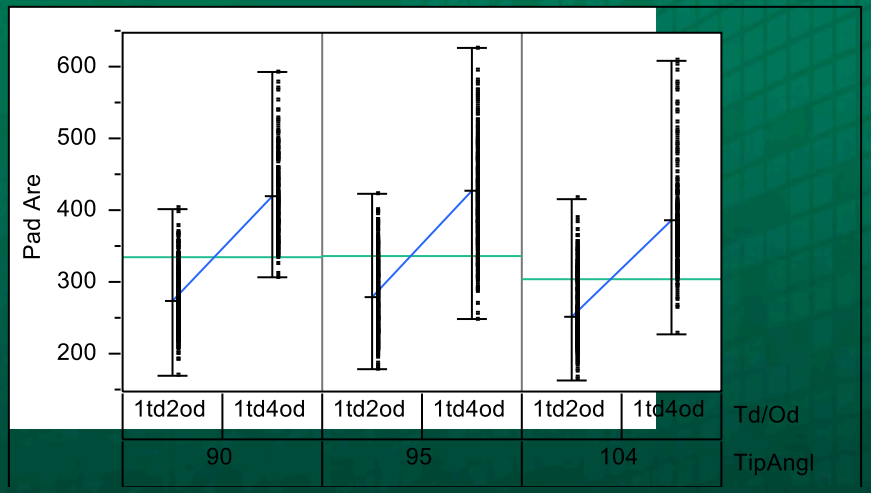
# Probe Mark Area: Probe Card D



# Card D: Overdrive, Tip Dia, Angle



# Conclusions for Probe Mark Area

- **Major factors in large probe mark area:**
  - high force cantilever probes
  - high overdrive
- **Minor factors:**
  - large tip diameter
  - (<104° tip angle)
- **No effect:**
  - Probe tip length

# Future Work

- Wirebond evaluation and reliability testing on various probe marks:
- Au, Cu, Ag-alloy, … wire types
- Ball bond, wedge bond
- Finite element modeling

❖IMAPS International Symposium 2013

❖IEEE EPTC 2013

# Acknowledgements


- **Supported by ON Semiconductor Quality & Reliability Management**
- **Significant contributions by ON Semiconductor personnel in Pocatello, Idaho:**
  - Pocatello Pilot Line
  - Materials Analysis Lab
- **University Electrical Engineering Departments:**
  - Idaho State University
  - Brigham Young University Idaho