SWTW 2-0-1-8

SW Test Workshop

Semiconductor Wafer Test Workshop

Effects of Pad Structure on the Scrub Performance of MEMS Probes for Memory Devices

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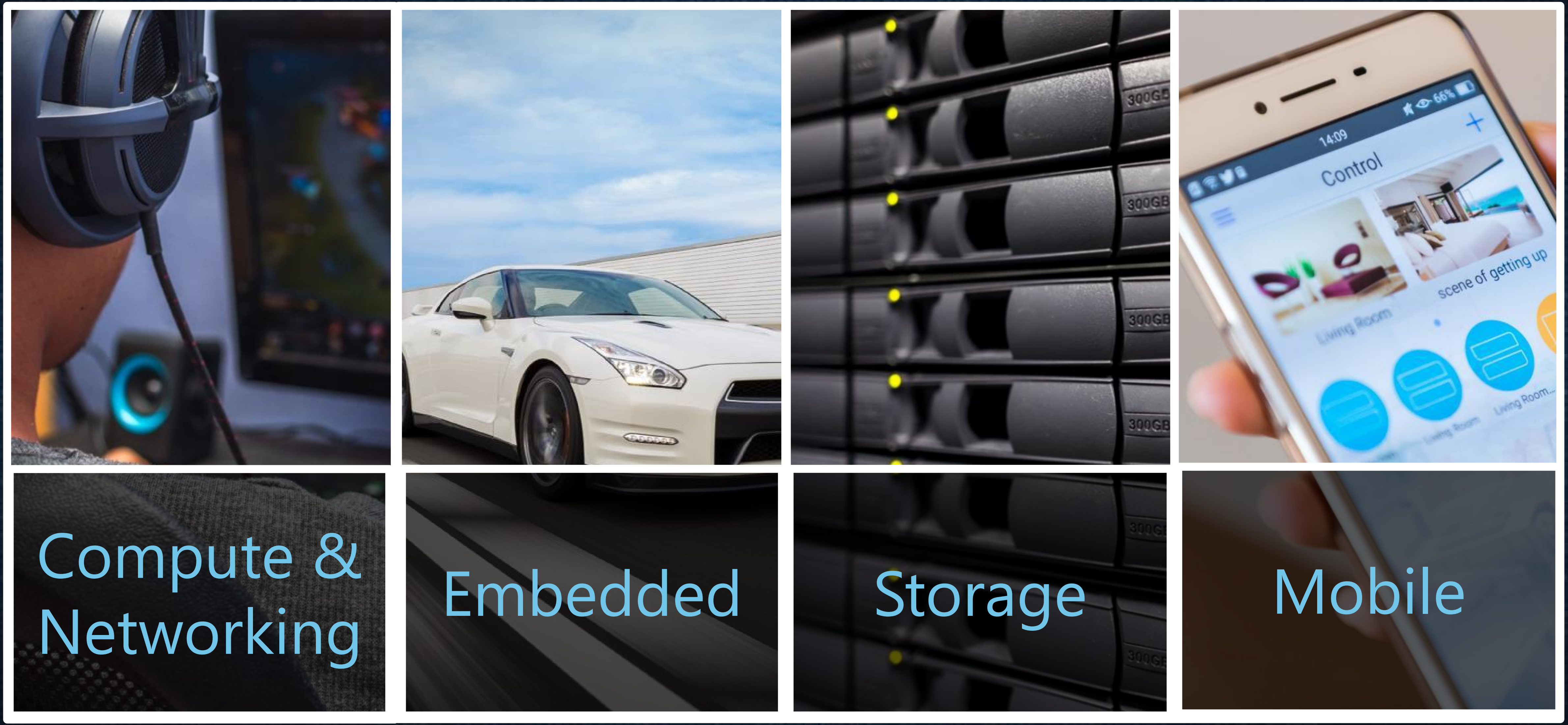
Outline

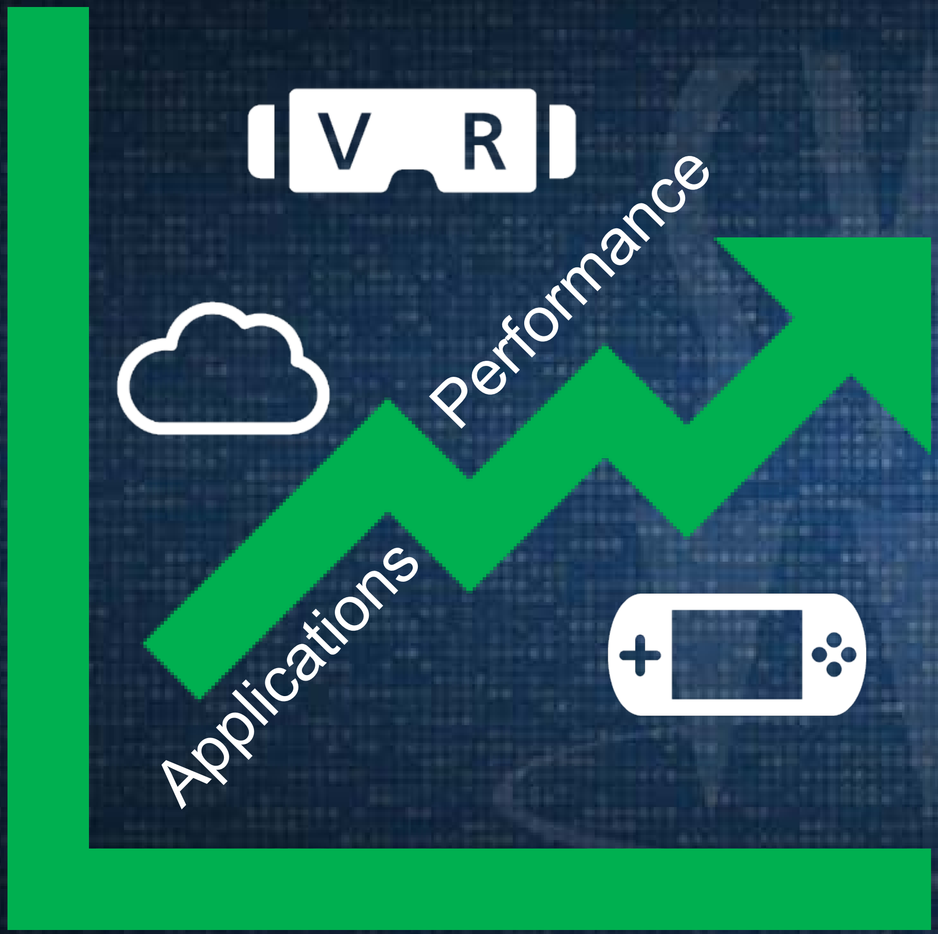
- Background / Trends / Test Requirements
- Experiment Design
- Results
- What Ifs
- Summary

Background

Diversified Memory Market



Industry Trends



Industry Trends

Implications for wafer test

- Smaller pad size
- Thinner pad metal
- Increased test insertions
- Higher die-per-wafer / increased parallelism

Generic Wafer Test Requirements

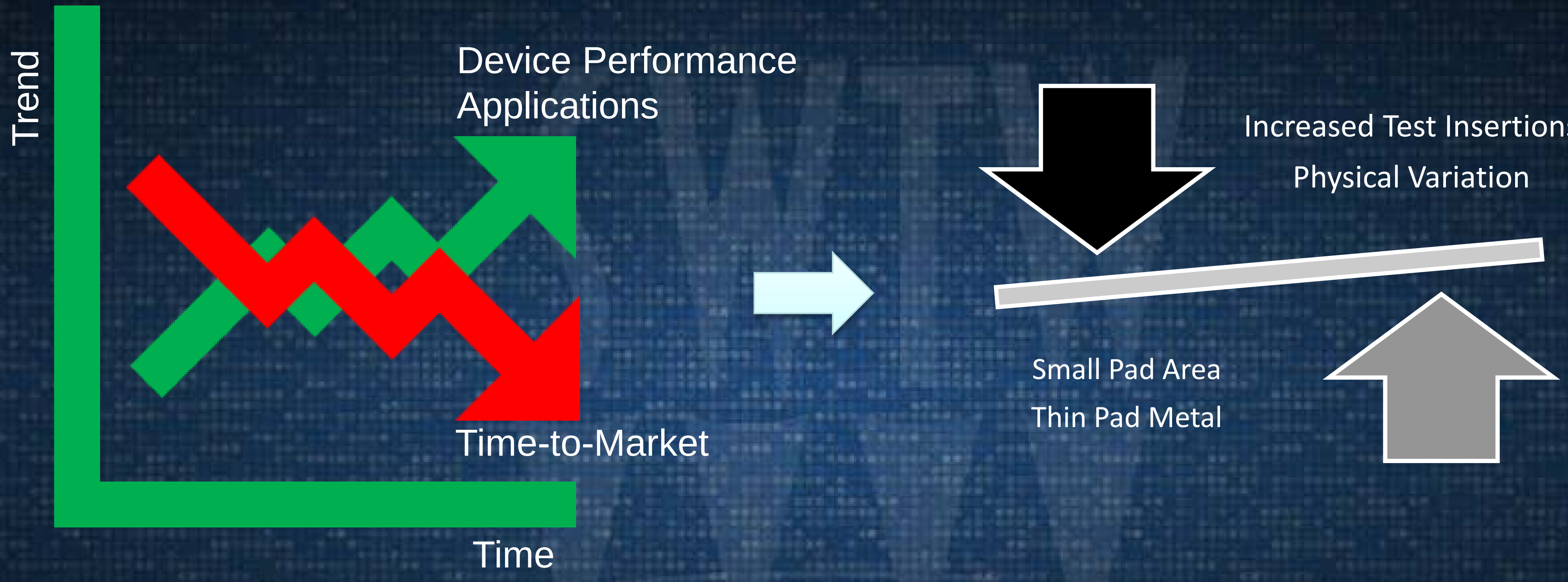
Scrub Depth < Pad Thickness

All Probe Marks Inside the Pad Boundary

100% Electrical Continuity

Dual Temperature Capability

The Challenge

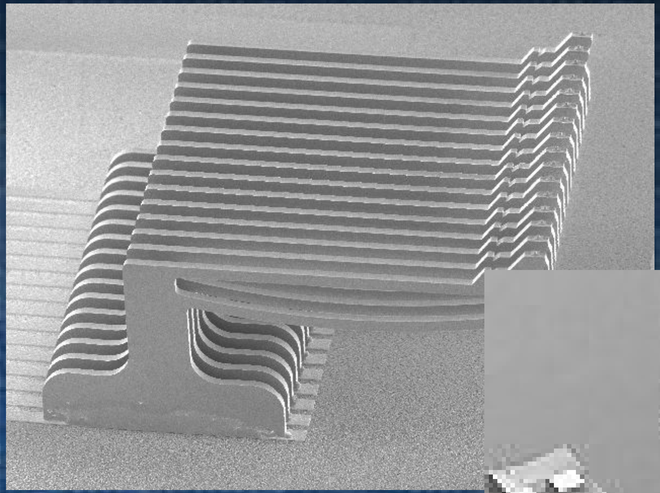


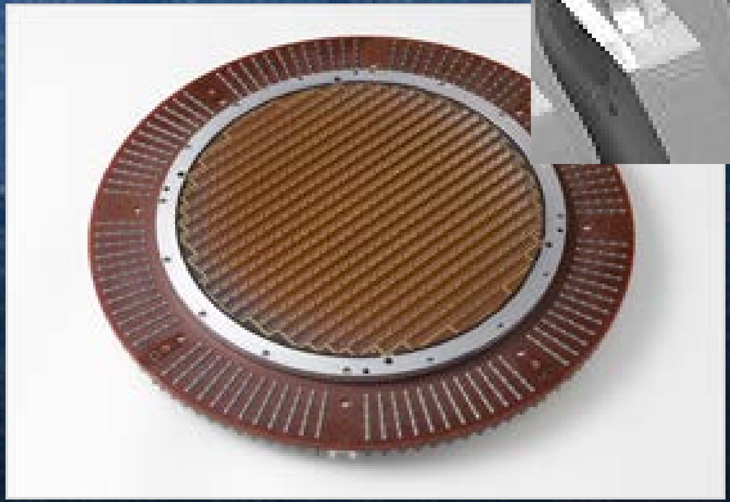
- **Balance scrub depth vs. scrub size to meet pad dimension reductions for devices with a breadth of physical properties**

Experiment

Advanced Probe Cards for Memory Devices

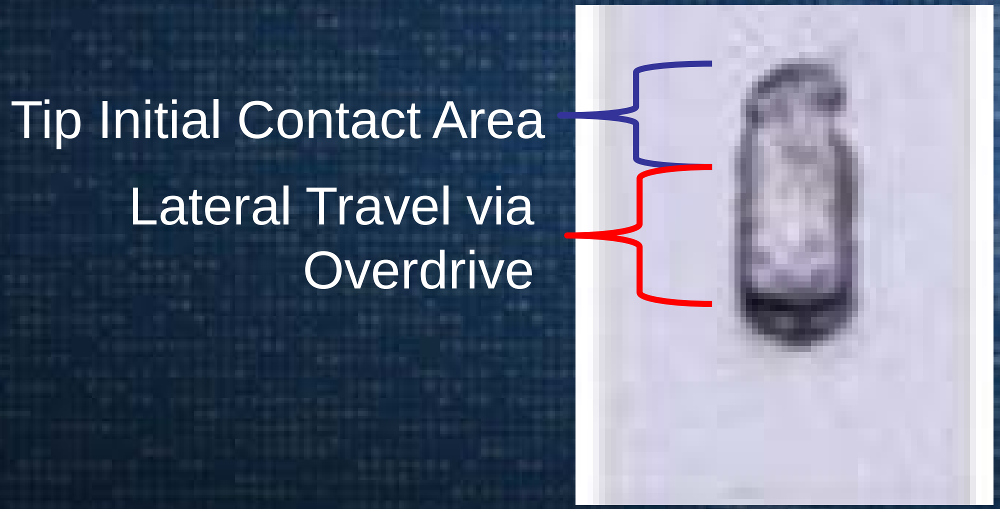
- "Micro-Cantilever" MEMS
- Full 300mm Probe Arrays
- >100,000 Probes per Array

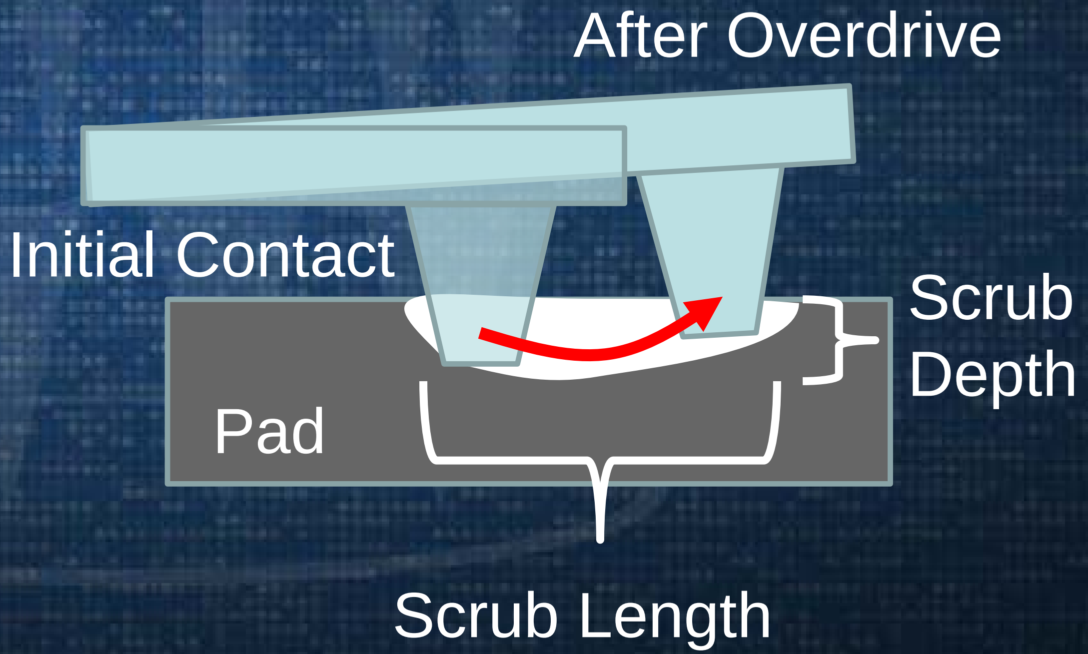




MEMS Probe Key Characteristics

- **MEMS "Scrub" – Vertical + Lateral Pad Contact**
  - Scrub Ratio (Length vs. Overdrive)
  - Probe Force





Evaluation Items

- **Micron and MJC evaluated the following:**

Evaluation Item	Variables	Measured Value
Scrub Characteristics Single Contact	Overdrive Tip Size	Length Width Depth
Scrub Characteristics Multi-Contact	Overdrive Tip Size Contact Count	Length Width Depth

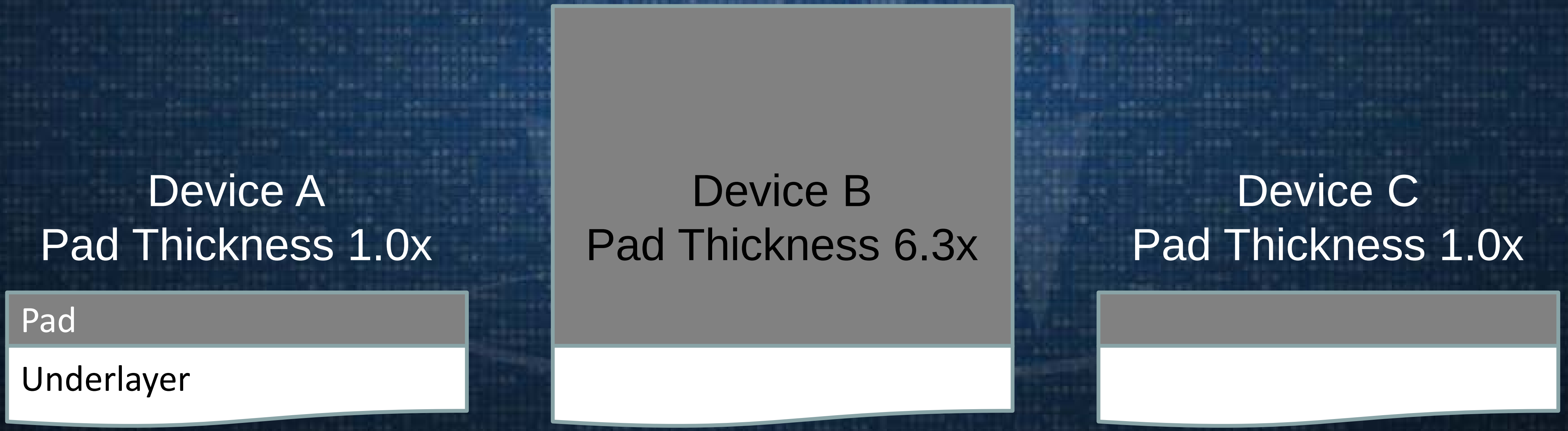
Conditions and Factors

- **Four different probe tips were evaluated on three different devices**

Item	Value
Wafers	Device A, B, C
Prober	300mm Wafer Prober
Temperature	Room Temperature
Probe Tip Type	1: Baseline 2: +70% Tip Area 3: +13% Probe Force 4: +13% Probe Force, +70% Tip Area

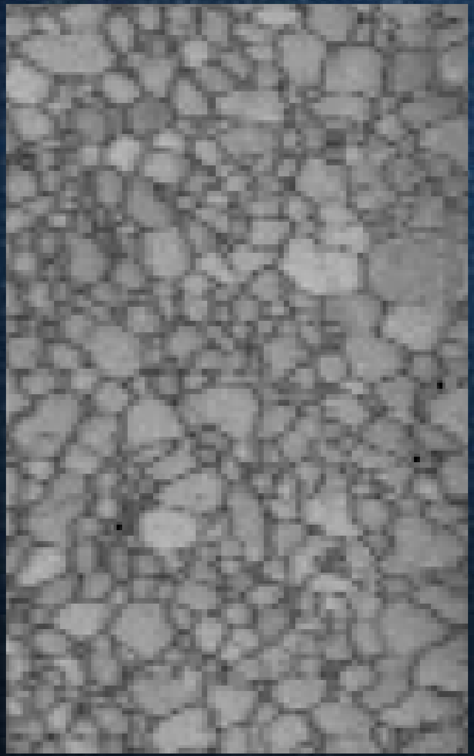
Device Probe Pad Characteristics

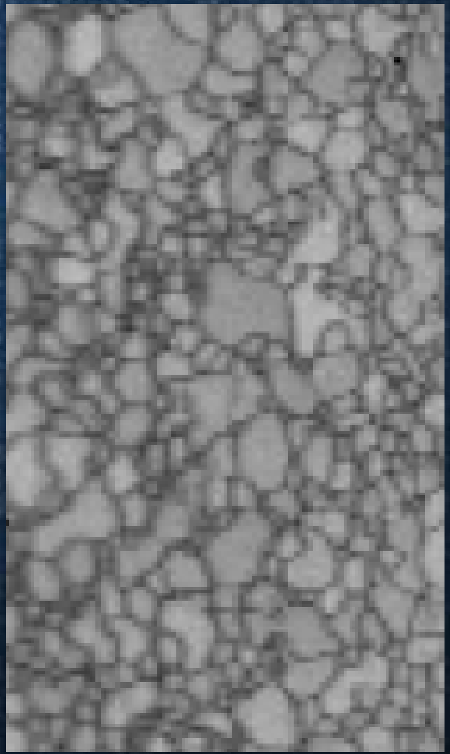
- **Pad Thickness Comparison**
  - Other properties (Pad Material, Surface Oxide, Hardness, Modulus) do not differ significantly



Device Probe Pad Microstructure Comparison

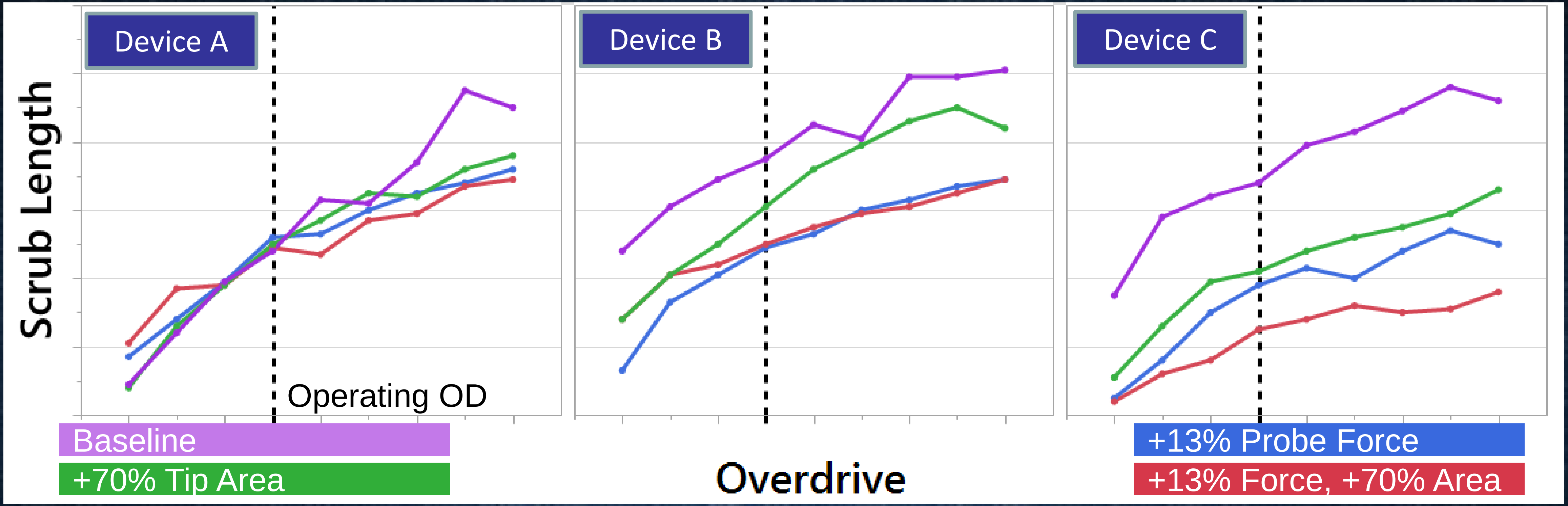
Device A	Device B	Device C
Grain Size: 1.0x	Grain Size: 4.6x	Grain Size: 1.3x
%GB > 15°: 50.0x	%GB > 15°: 29.0x	%GB > 15°: 1.0x





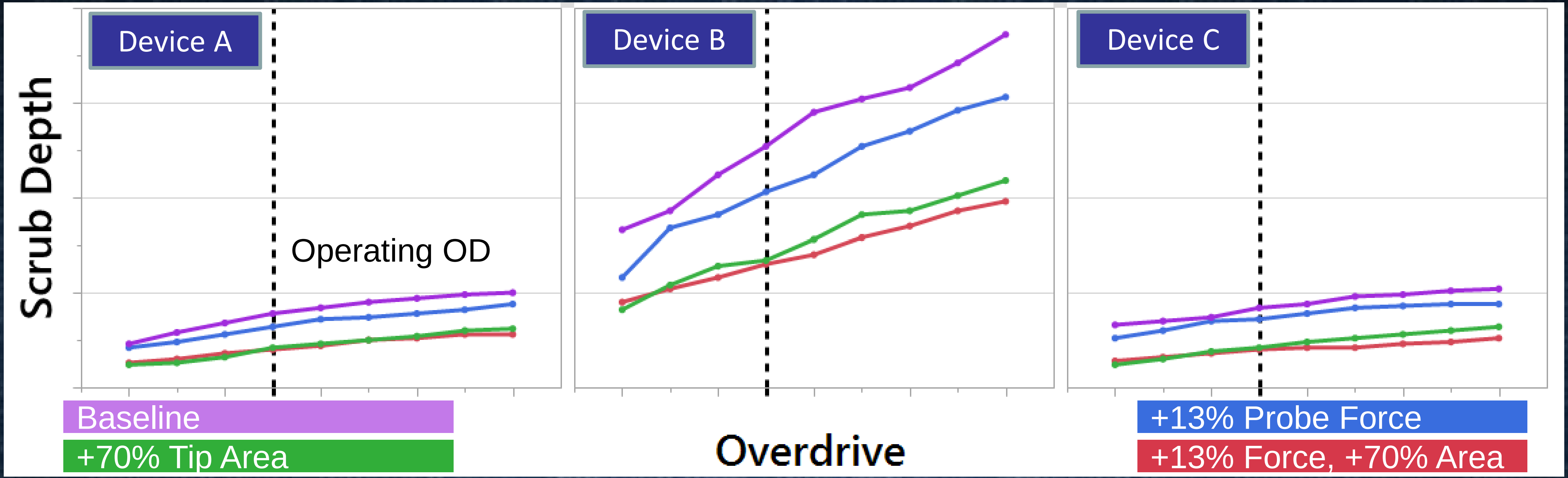
Results

Char Results – Scrub Length, Single Contact



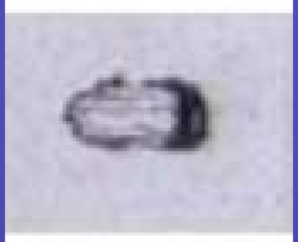
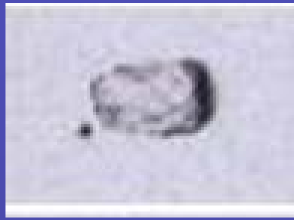
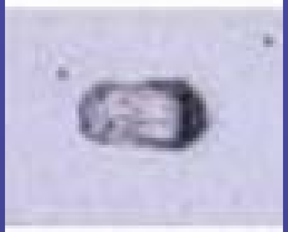
- **Scrub Ratio characterization to determine AOT/POT is device-dependent**
- **Unpredictable effect on scrub length of changing tip characteristics**

Char Results – Scrub Depth, Single Contact

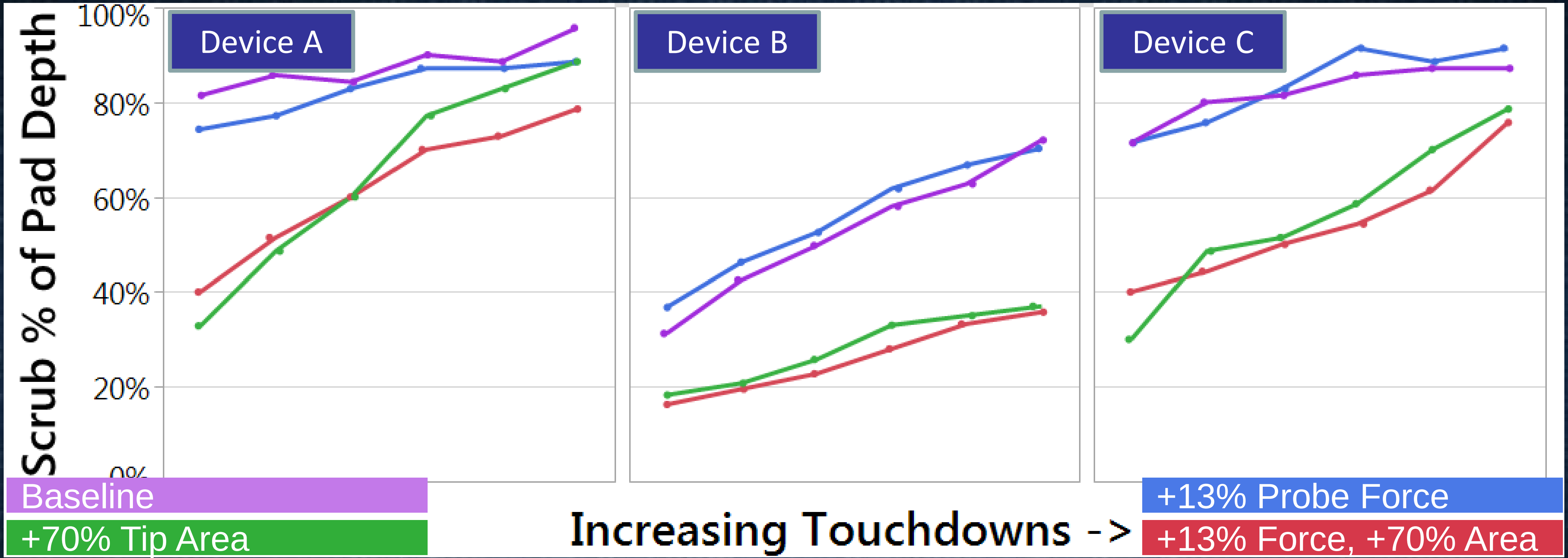


- Scrub depth response of a given probe tip varies by pad thickness
- Tip size is the dominant factor in determining scrub depth

Scrub Mark Images @ Operating Overdrive

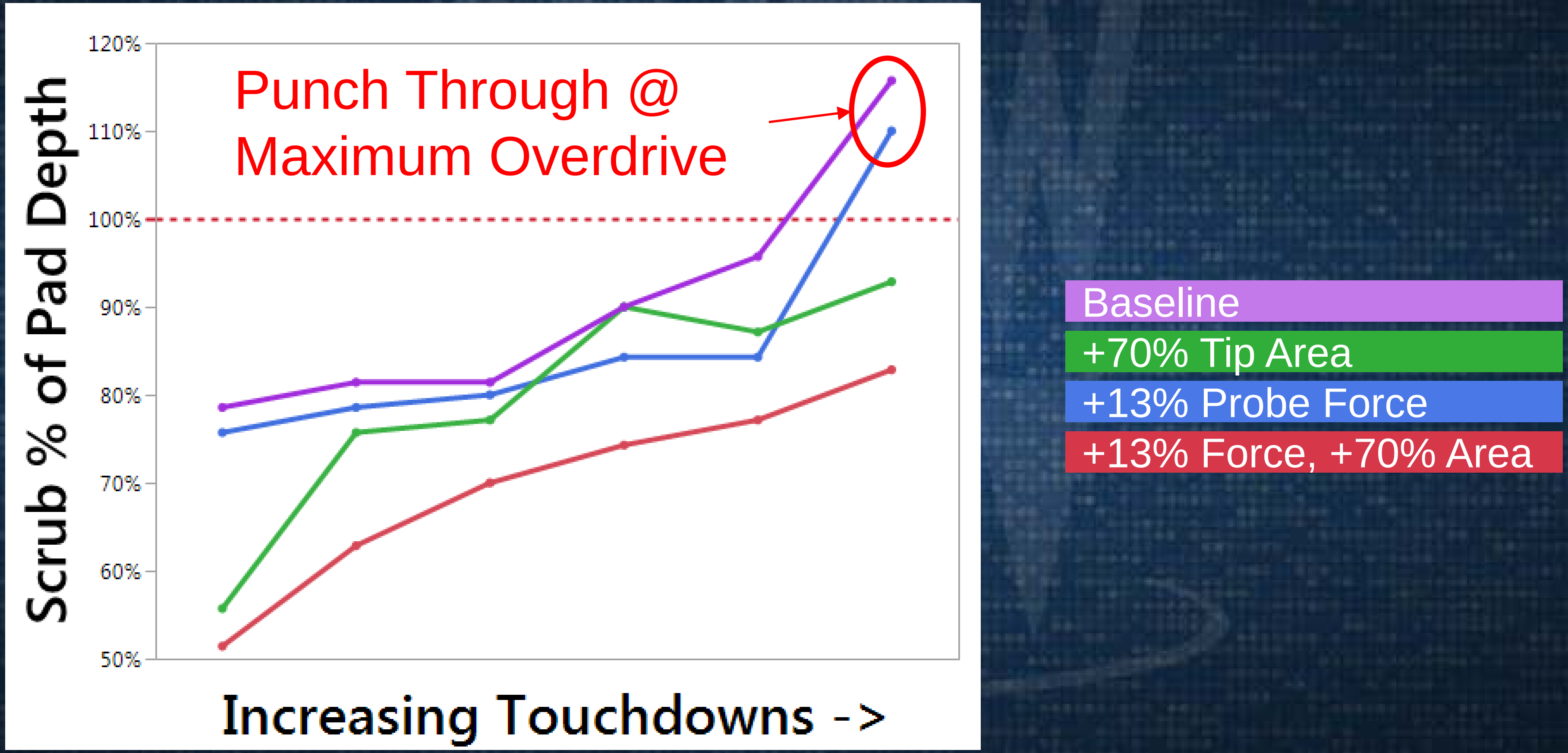
	Baseline	+70% Tip Area	+13% Force	+13% F, +70% A
Device A				
Device B “The Bulldozer”				
Device C				

Char Results – Punch Through, Multiple Contacts



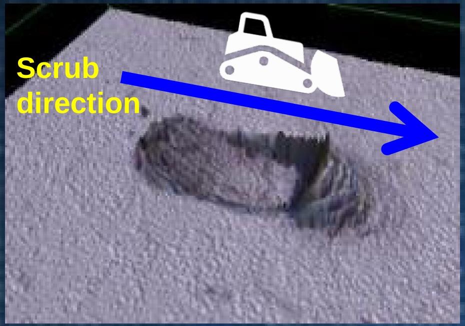
- **Scrub depth approaches a limit at ~80-90% of pad depth**
- **Force characteristic has little to no impact on scrub depth.**

Punch Through Observed on Device A



Scrub Depth Images – MJC Confocal Scope

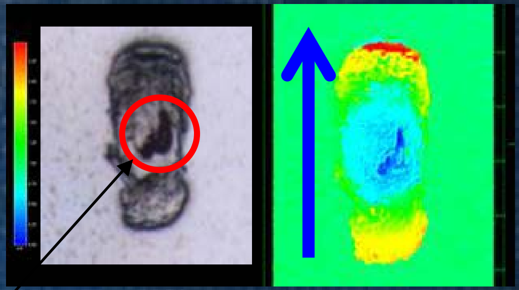
Device B, Baseline Probe Tip



Single Contact

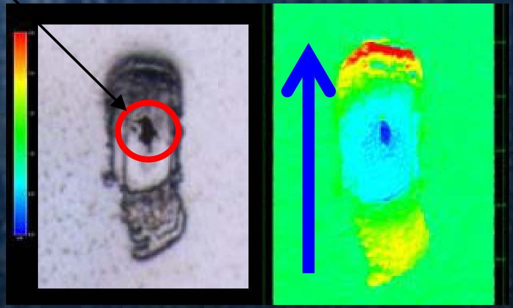
Multi-Contact

Device A, Baseline Probe Tip



Multi-Contact

Punch Through

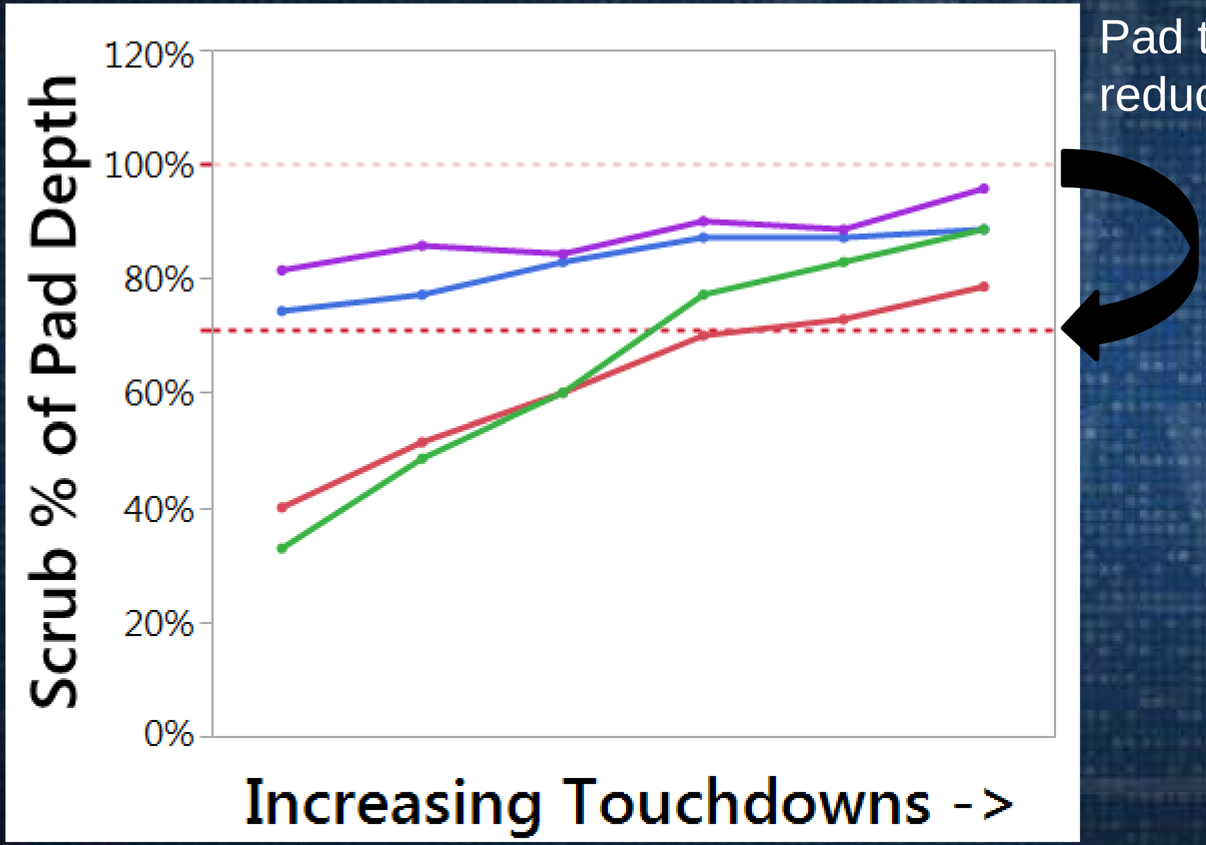


Multi-Contact +

Additional Considerations

What If…Pad Metal Becomes Thinner?

Device A @ Operating OD



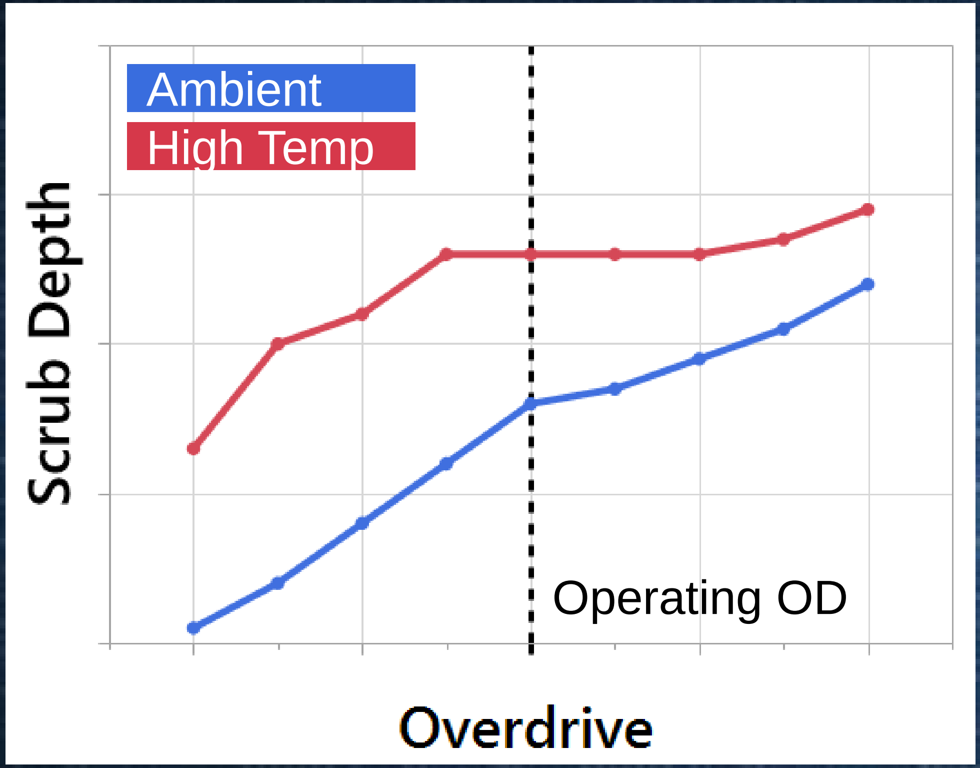
Pad thickness reduction of 30%

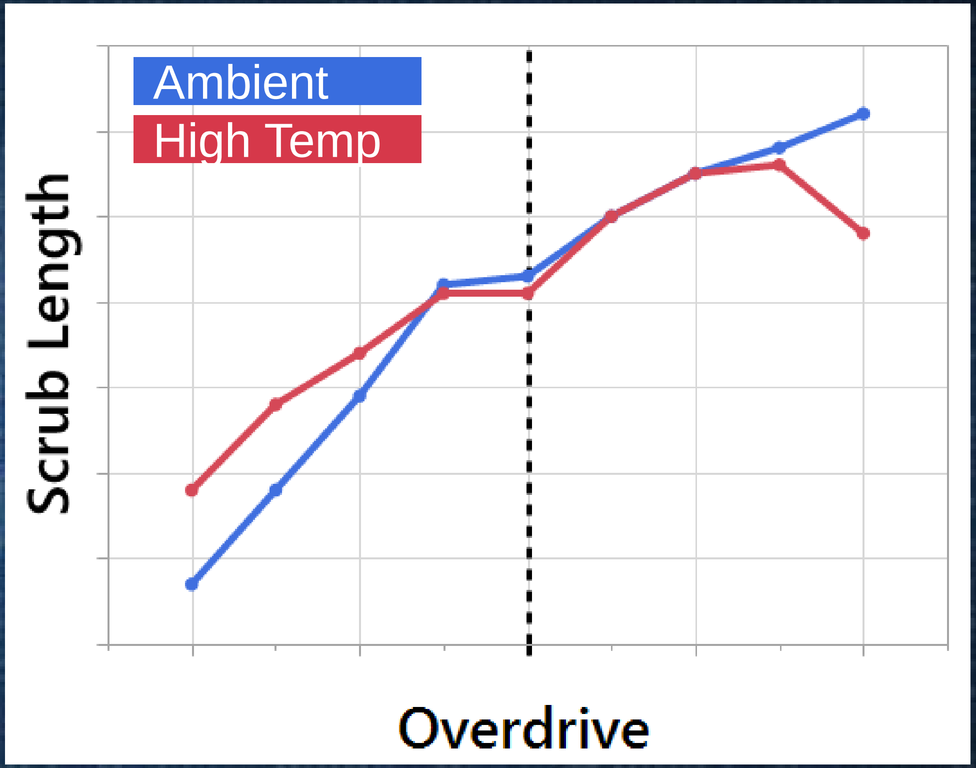
- Baseline
- +70% Tip Area
- +13% Probe Force
- +13% Force, +70% Area

- **Potentially punch through on the first contact with small tips**
- **Large tips may not punch through (assuming pad hardening occurs); marginal at best**

What If…Testing Temperature Increases?

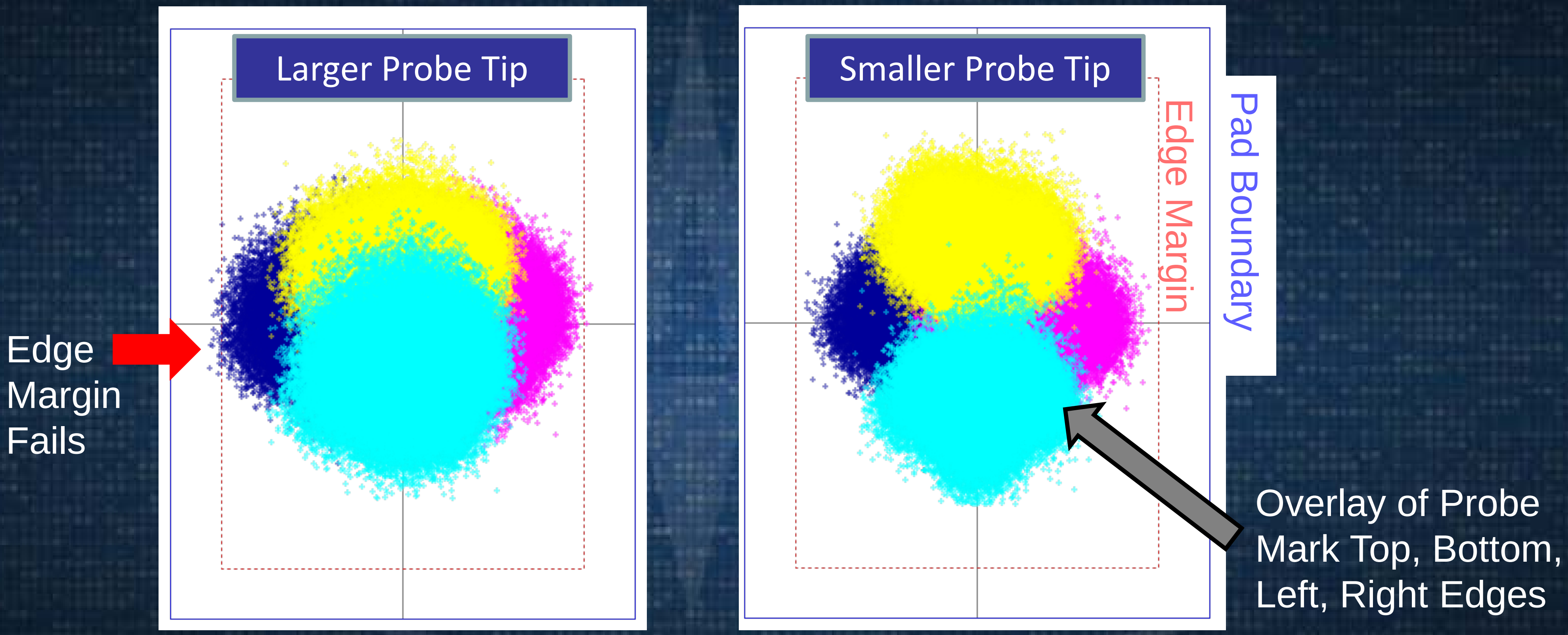
Device A, Probe Tip: +13% Force, Baseline Area





- **Scrub depth shows high temperature dependence; length does not**
- **Scrub depth rate of increase slows at high overdrive**

What If….Pad Size Shrinks?



- **Larger tip area = reduced scrub depth, but edge margin is strained**

Summary

Summary

- **Scrub characterization of probe types is critical to understanding advanced probing processes**
  - Depth and length can vary significantly across a breadth of similar devices
- **To meet the challenge of reduced pad dimensions, an array of probe tip offerings from probe card suppliers is necessary**
  - Varying tip area for optimized scrub depth
  - Varying tip size for optimized pad edge margin
  - The “right” balance of tip area vs. tip size

The Gap

- **Innovation Required:**
  - Can the probe card industry develop a one-size-fits-all probe tip for tomorrow's device requirements?
  - Or, can probe card suppliers cost-effectively produce an array of probes tailored for specific device properties?

Final Thoughts

- **Cooperative partnerships are critical in developing solutions for next-generation probing processes**
  - "Thank You" from Micron to MJC and MEC for partnering in this study

- **Acknowledgements**
  - Micron Technology: Kurt Guthzeit, Alistair Laing
  - MJC: Miho Kitayama, Yuma Tanaka
  - MEC: Dick Duncan