SWTEST 2026 CONFERENCE

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The Ever-Increasing Challenge of Probe Card Power Delivery

Blake Rapp

Micron Technology, Inc.

Outline

- **Changes in requirements**
- **Key factors and impacts on PDN**
  - Higher signal densities
  - Probe contact resistance
  - Lower voltage droop tolerance
  - Power supply path length
  - Test temperatures
- **Conclusion**

Trends in Memory Device Requirements

VDD Decreasing (slowing)

Data Rate Increasing

- Frequency (change rate slowing)
- Data Channels (increasing)

Transient Effects Increasing

- Magnitude
- Slew Rate
- Burst Length

Time/Product Generations

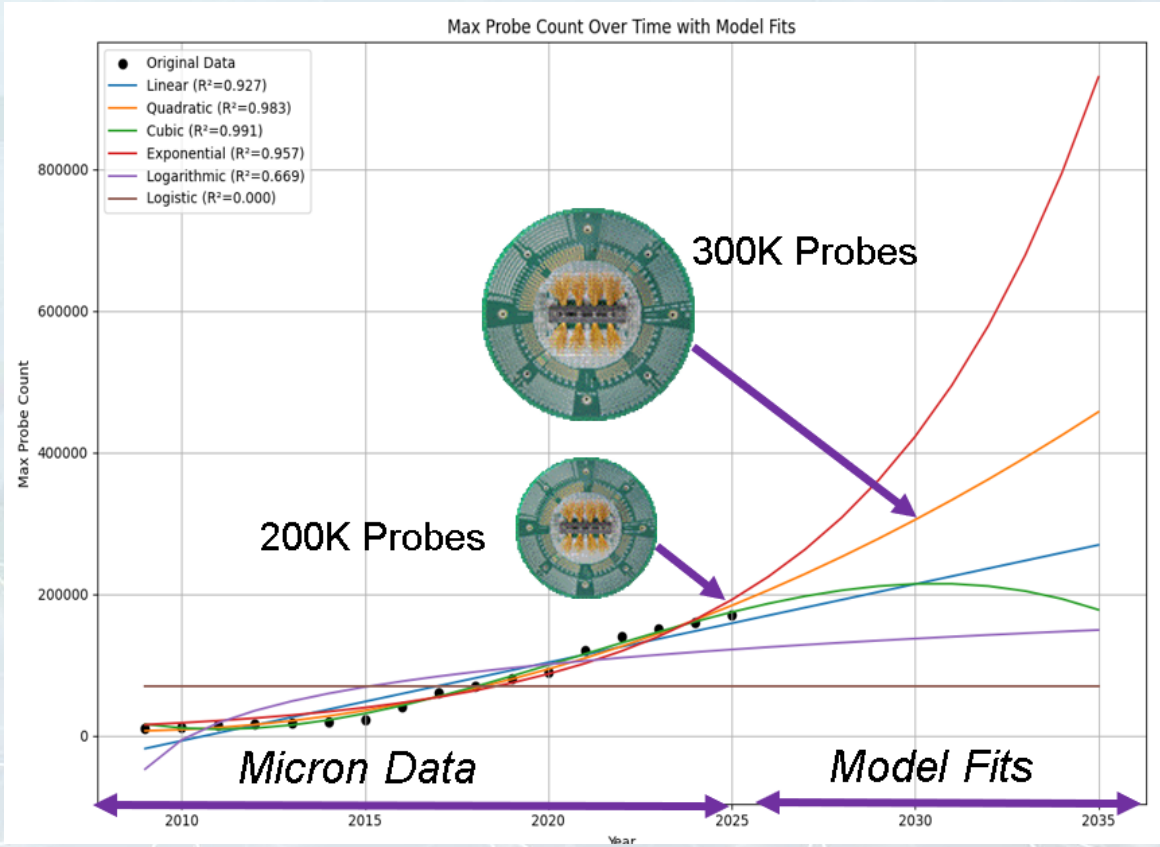
Performance

- Speed and bandwidth
- Reliability and fault tolerance

Improved performance drives more stringent test requirements

Key Factor: Higher Signal Density

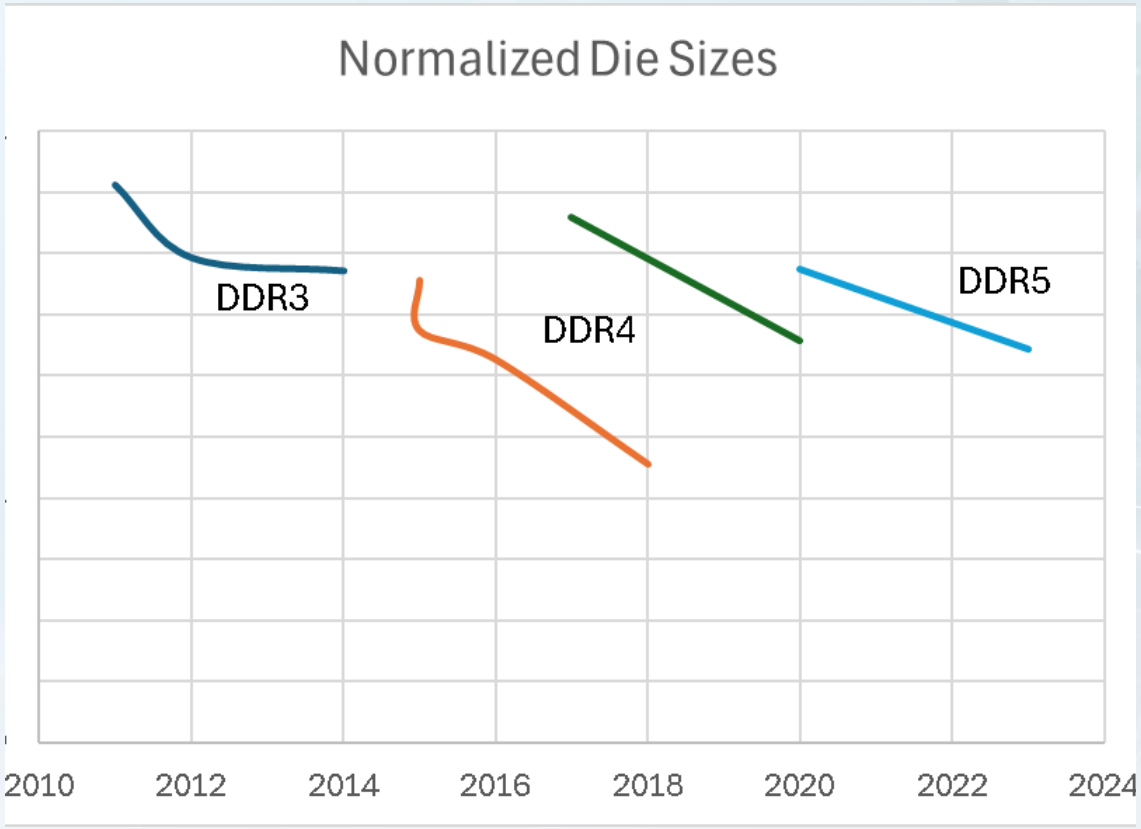
- **Contributors:**
  - Die size shrink (NVM, DDR, LPDDR)
  - Probes per die increase (HBM)
- **Implications:**
  - Less room for decoupling capacitors
  - Can impose constraints on probes per die depending on layout
  - Leads to smaller pad sizes that drive smaller probe tip size

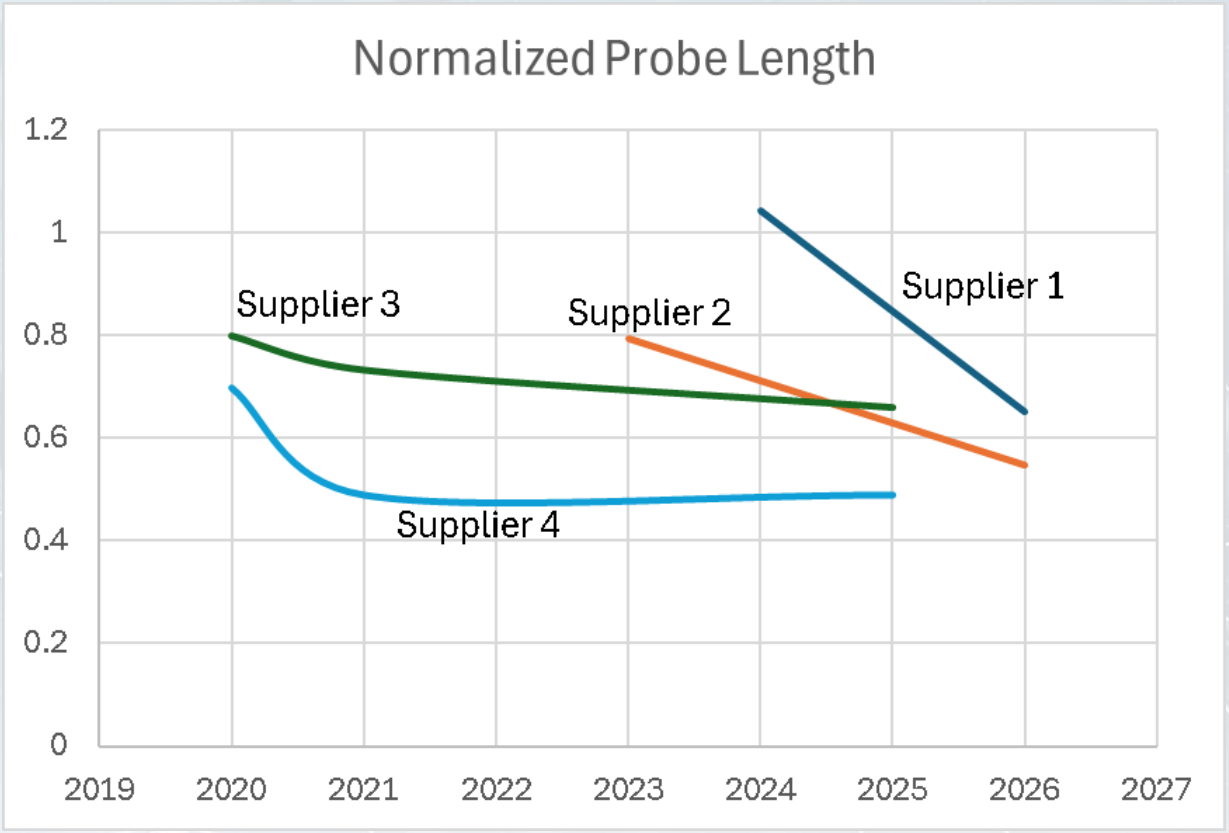


Reference: Alistair Laing, Micron 2025 SW Test Asia Fukuoka

Probe Length Reduction

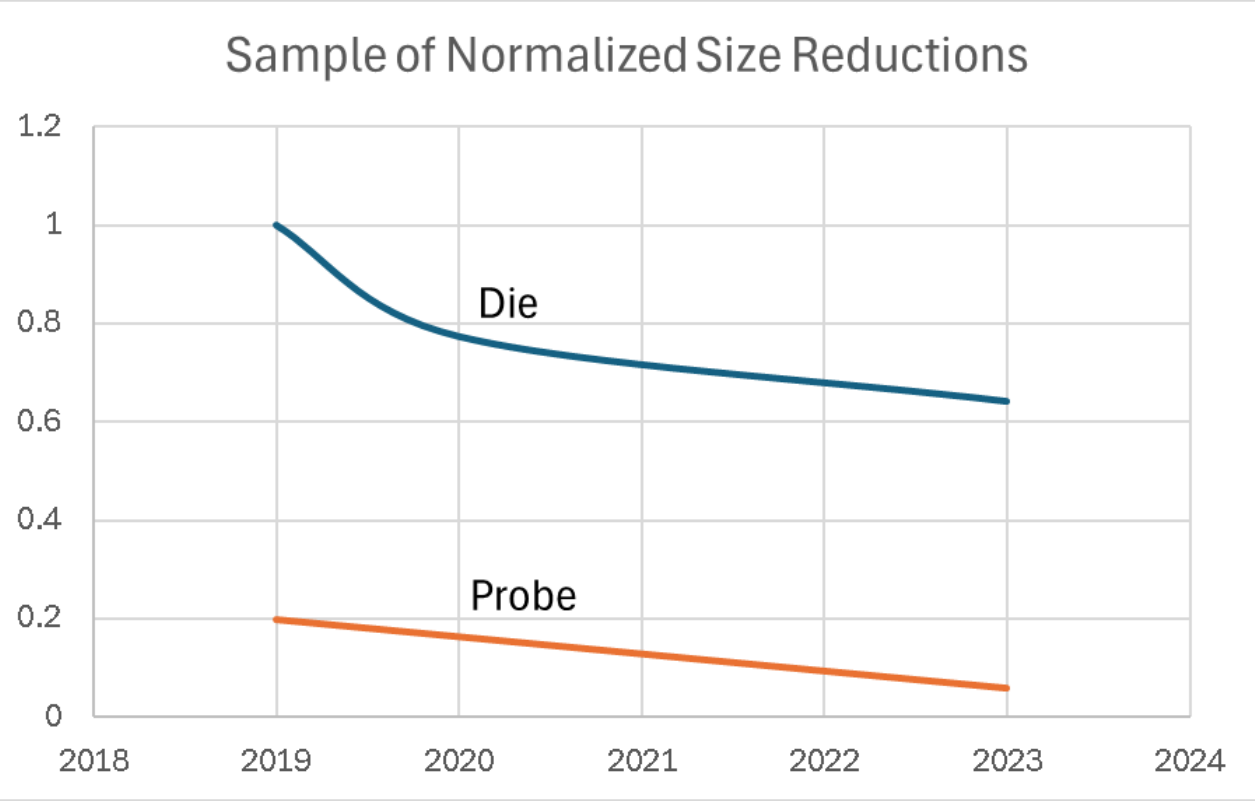
- Probe length and die size reduction rates are similar
- The scale of change is an order of magnitude different

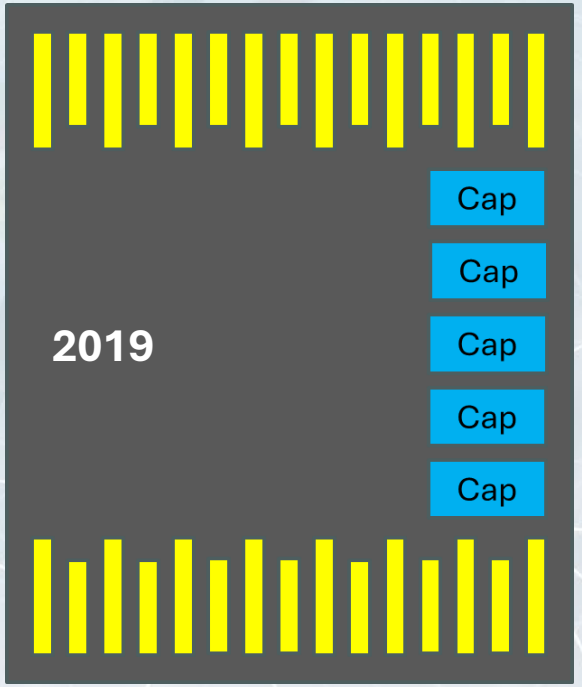


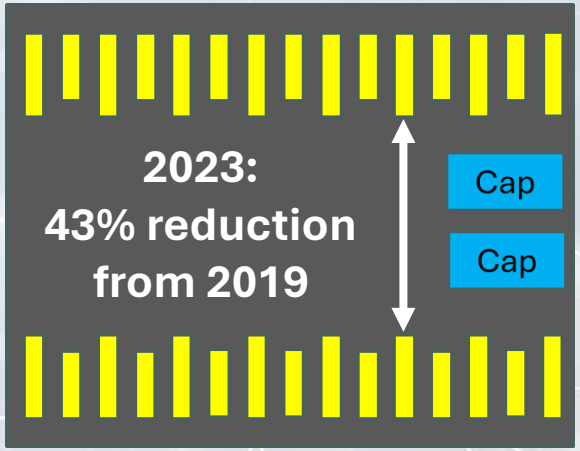


What Did That Mean?

- Die size decrease is a magnitude > probe length reduction
- Limits area for passive components

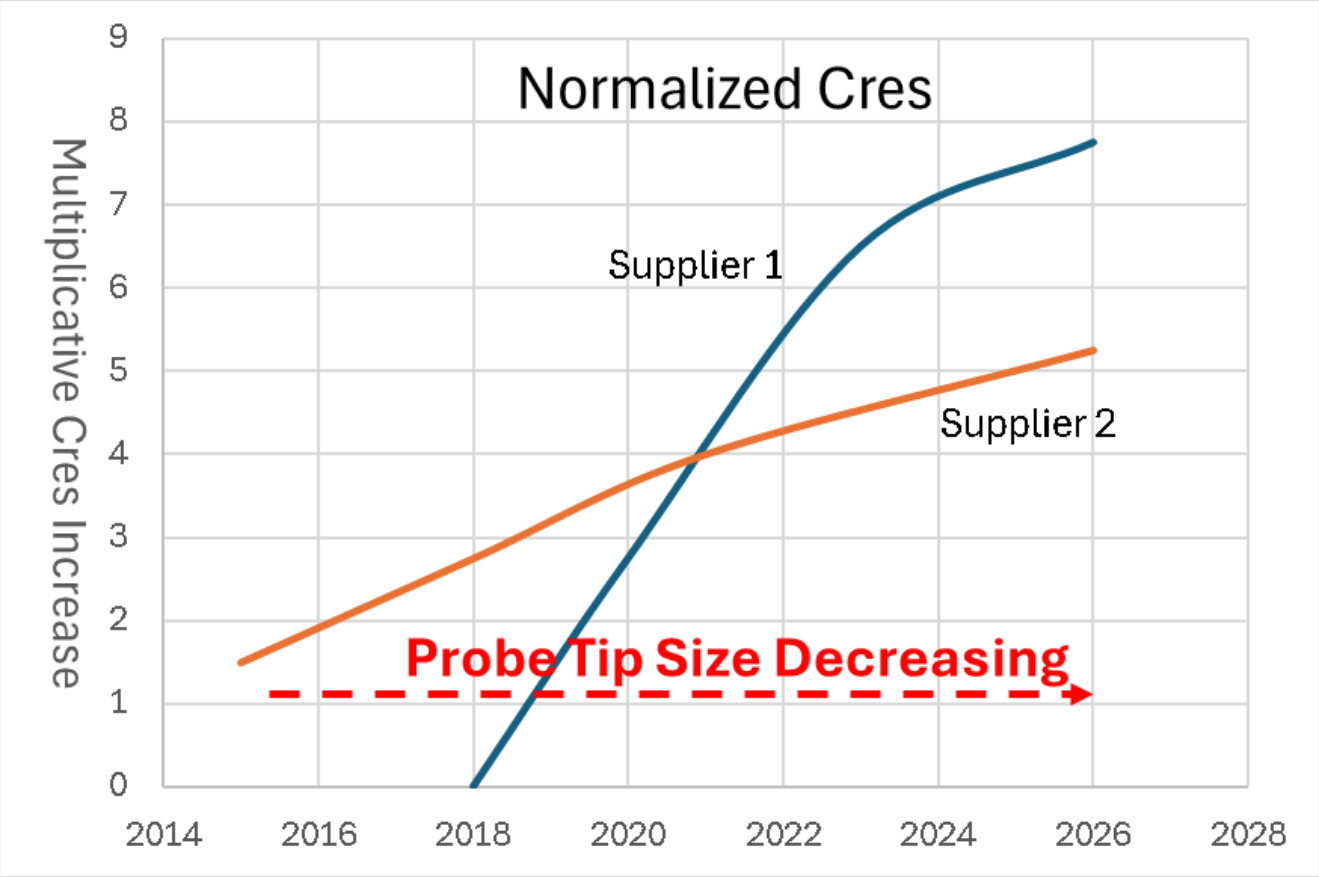


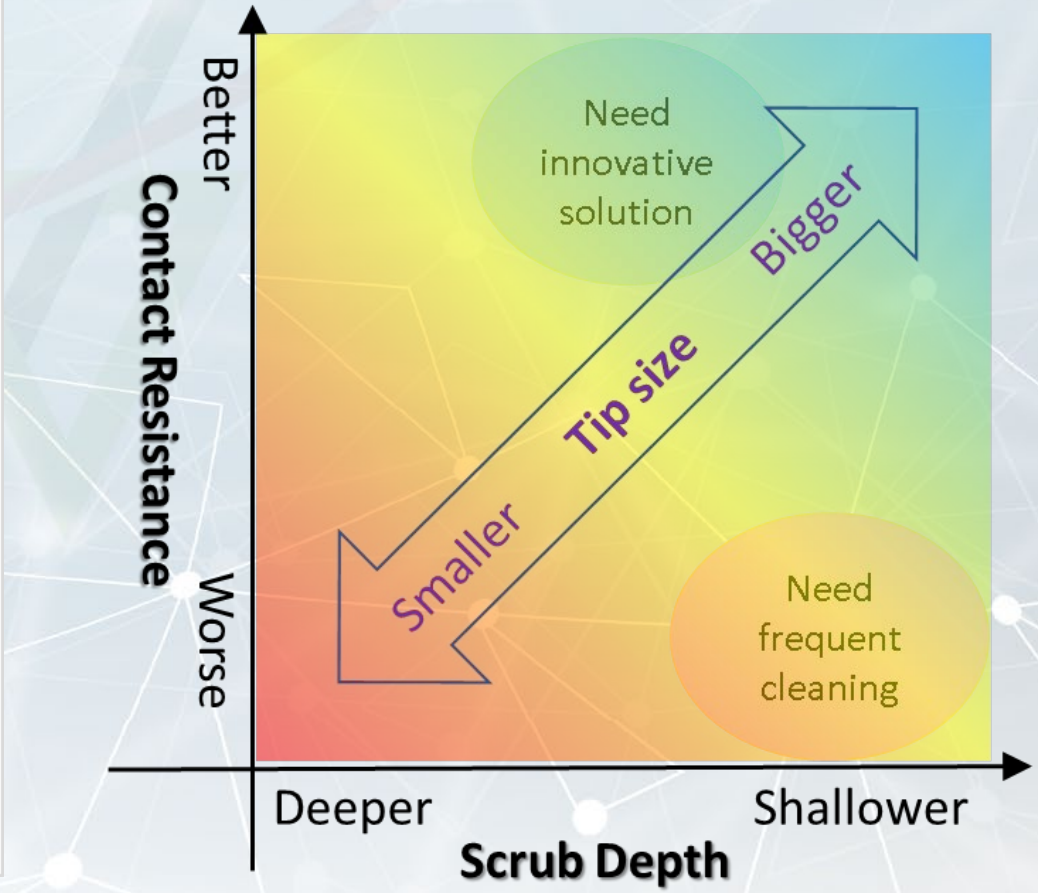




Key Factor: Probe Contact Resistance

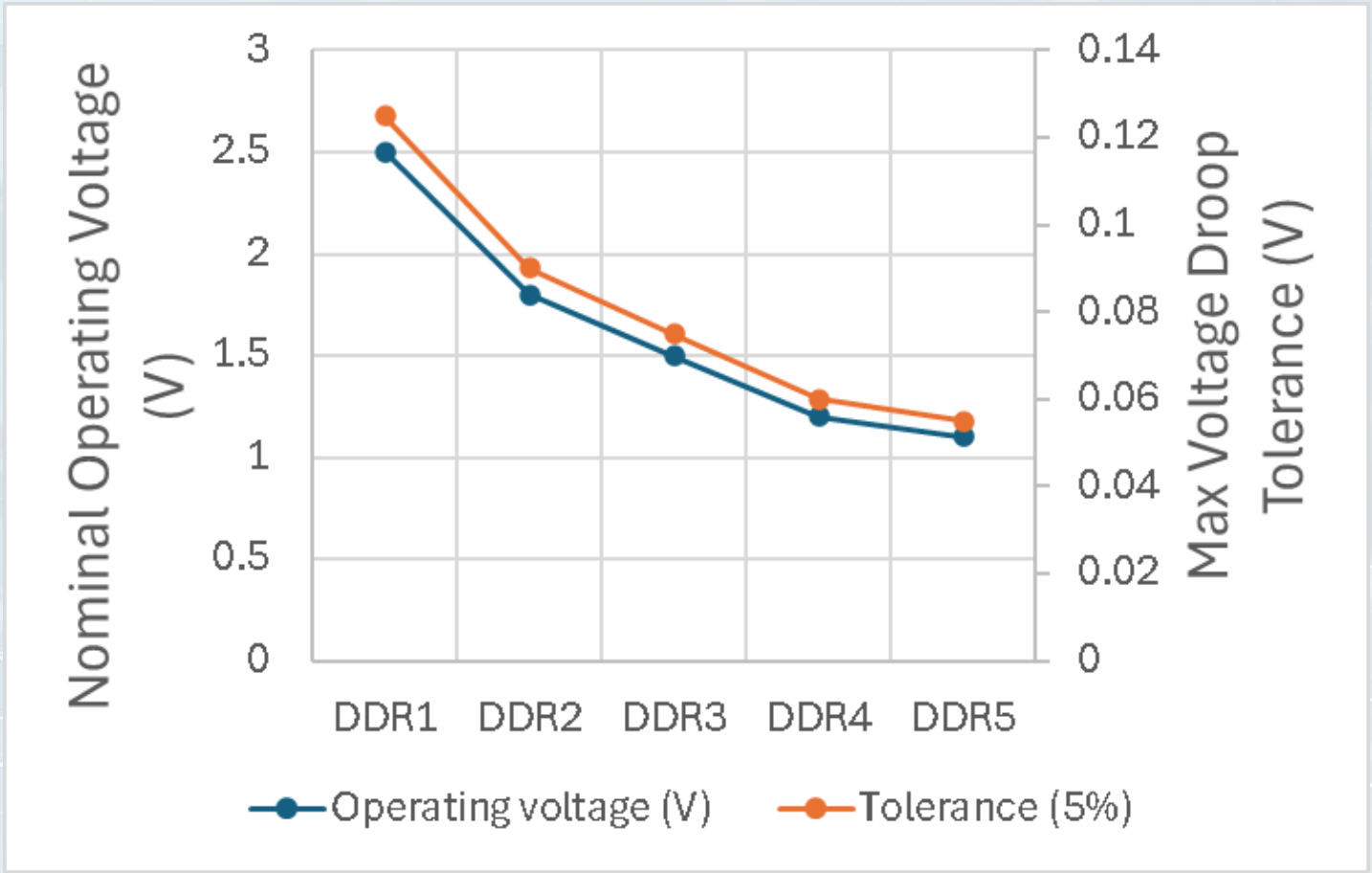
- **Contributors:** probe to pad interface, pad oxide layer, probe tip size
- **Implications:** voltage droop requiring compensation at DUT





Key Factor: Lower Voltage Droop Tolerance

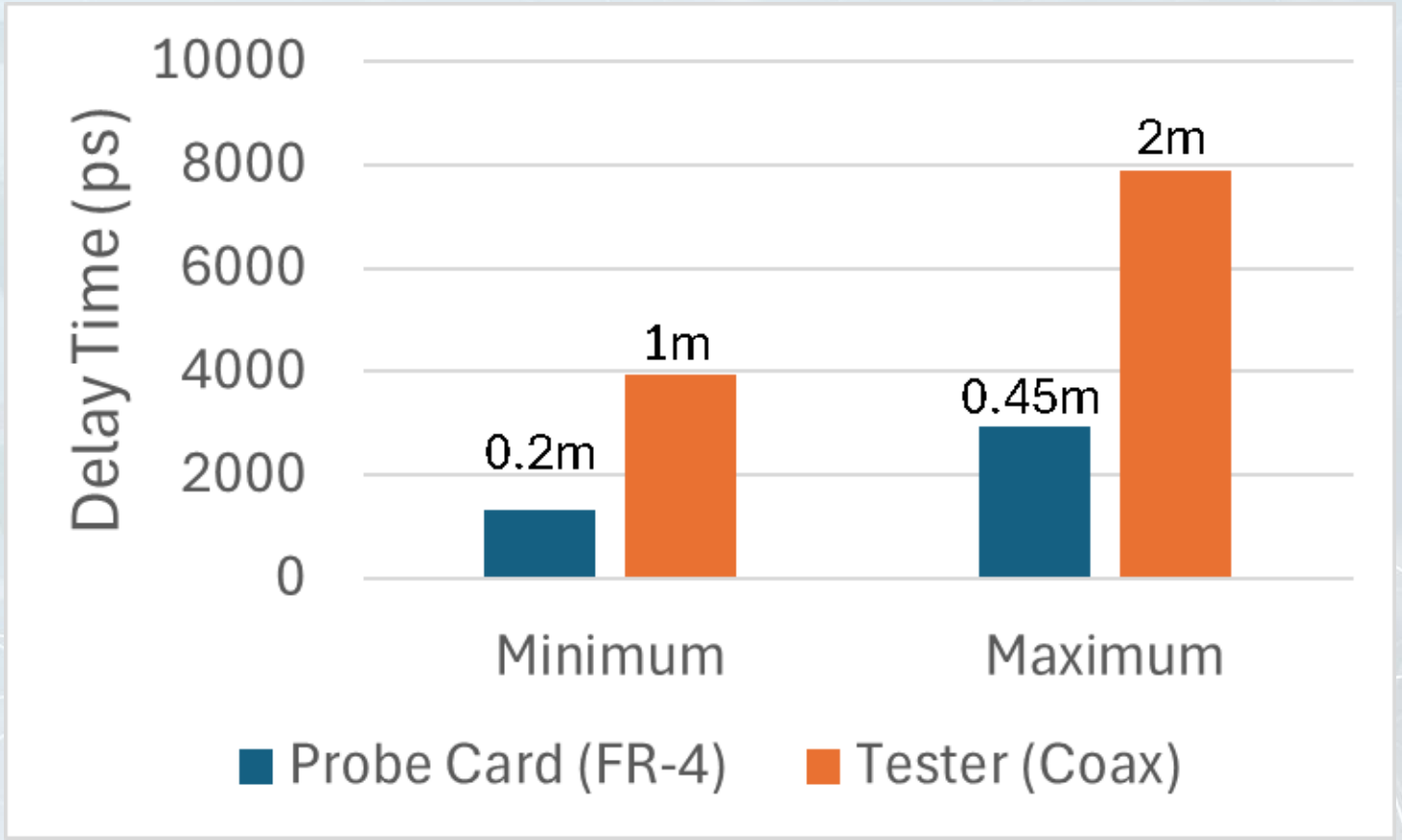
- **Contributors:**
  - Decreasing VDD
  - Selectable voltage settings allowing low-power modes for LPDDR6 and HBM
  - Increased data rates and/or number of data path sub-channels
- **Implications:**
  - Smaller voltage droop margin against lower VDD
  - Higher current transients during higher data rate operations



Summary of JEDEC guidance

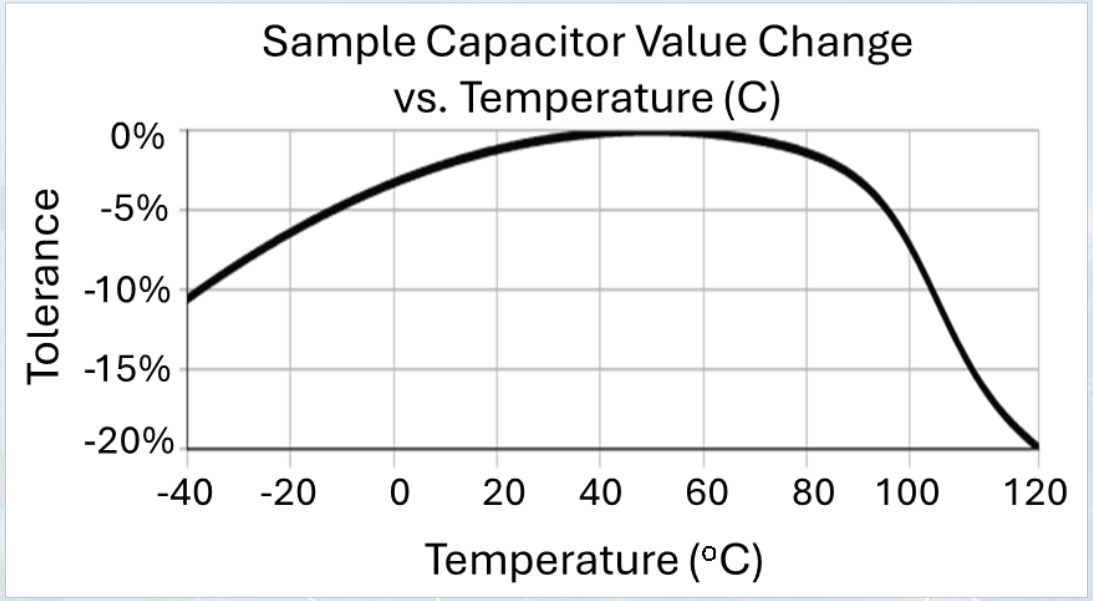
Key Factor: Power Supply Path Length

- **Contributors:**
  - Power supply and feedback paths remain unchanged as data rates/transient durations change
  - Inductive losses delay perceived power supply response
  - Resistive losses dilute power supply output
- **Implications:**
  - Die power demand delayed
  - PDN design issues can look like contact or SI problems in test results
  - Total path length round trip: 10 – 20 ns



Key Factor: Test Temperature

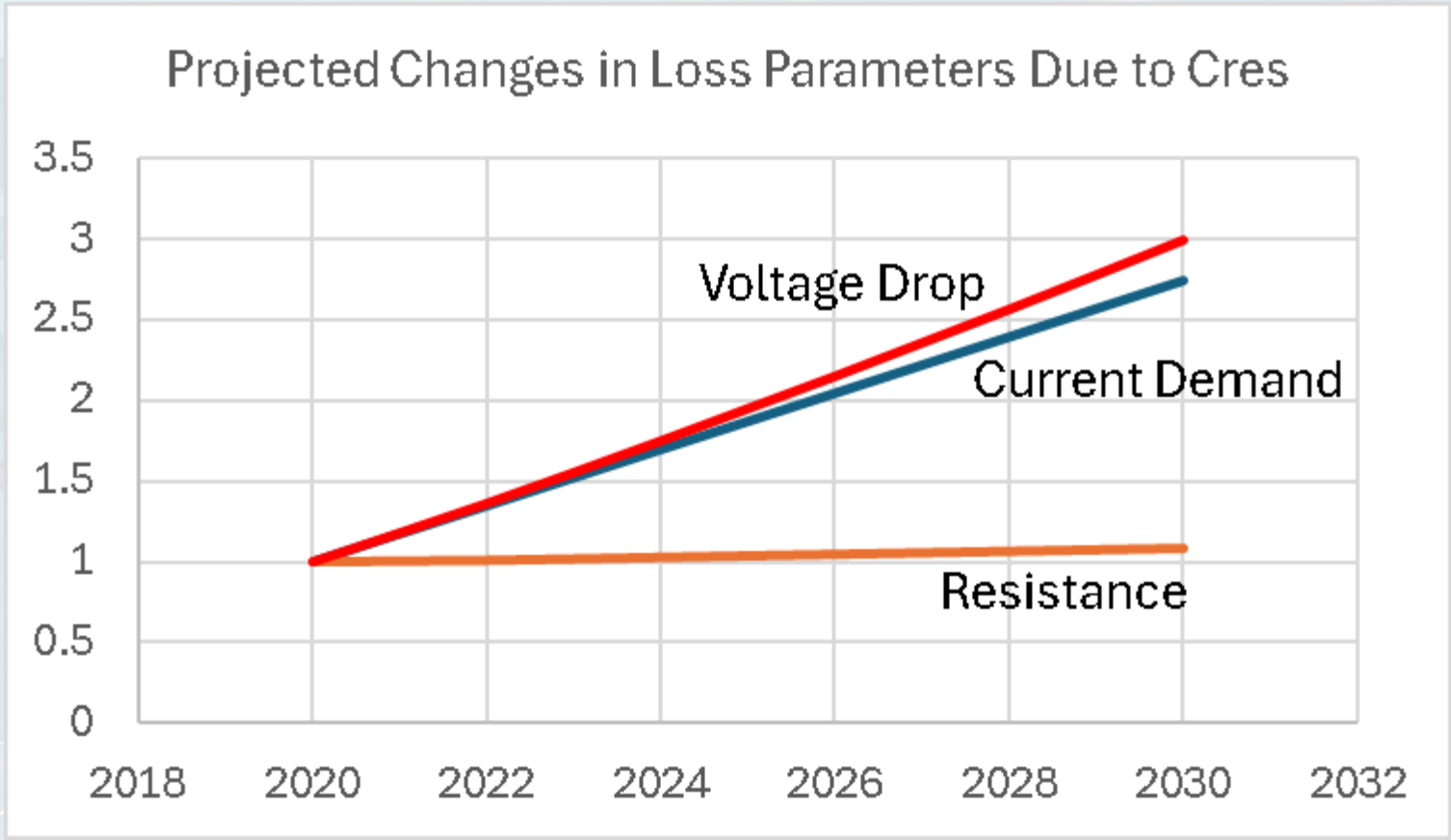
- **Contributors:**
  - Varying customer segments with different test condition requirements
  - AEC-Q100: -40C to 125C
- **Implications:**
  - Limits decoupling capacitor selection
    - Tolerances
    - Package size
  - Electrical properties of materials



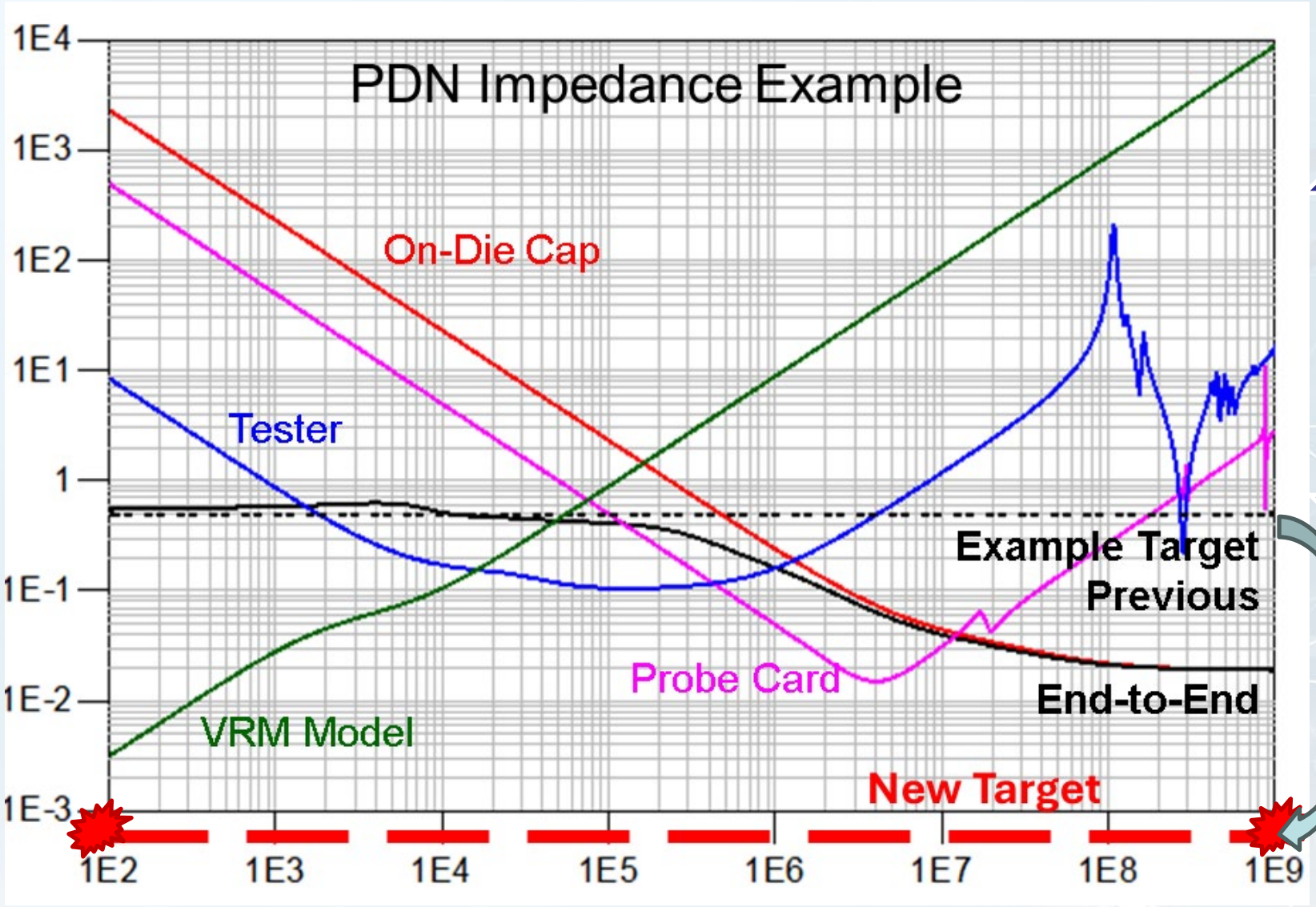
Size (SI/Metric)	Value (uF)	Temp Rating
0402 (1005)	0.047	X7R
	0.1	X7R
0603 (1608)	0.022	X7R
	0.1	X7R
	0.22	X7R
	1	X7R
	2.2	X7R

High-Current Emerging Memory

- **High current:** 1 – 2 orders of magnitude higher
- **Assumptions per two years**
  - 2x increase in Cres
  - 35% increase in current
  - No change in tester resistance
- **10-20 ns power supply response delay still present**



High-Current Emerging Memory (cont.)



Test Requirements

Data Rate and Current

Vdroop and Impedance Target

Test requirements lead to compromised test conditions

Industry Opportunities

- **Novel techniques reduce inductance, increase decoupling**
  - Targeting reduced PDN impedance budget
  - Increasing probe count while managing probe force
- **Measures to reduce DC resistance, mainly in probe cards**
- **Alternate methods to improve power supply reaction time while avoiding ringing/runaway**

Acknowledgements

- Special thanks to…
- Kingle Wang for technical guidance and insights
- My coworkers and leadership for their guidance and the opportunity
- Multiple Micron teams for experimental feedback
- Micron’s industry partners for collaboration and feedback

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Thanks for Joining!

Questions?

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Blake Rapp

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