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Semiconductor Wafer Test Workshop

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A New Methodology for Assessing the Current Carrying Capability of Probes used at Sort

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Overview

Background

ISMI Methodology (presented at 2009 SWTW)

New Current Carrying Capability (CCC) Methodology

- Experimental Setup
- Determining k_{probe}
- Current Spike Testing
- Lifetime Reliability Testing
- CCC Failure Criterion

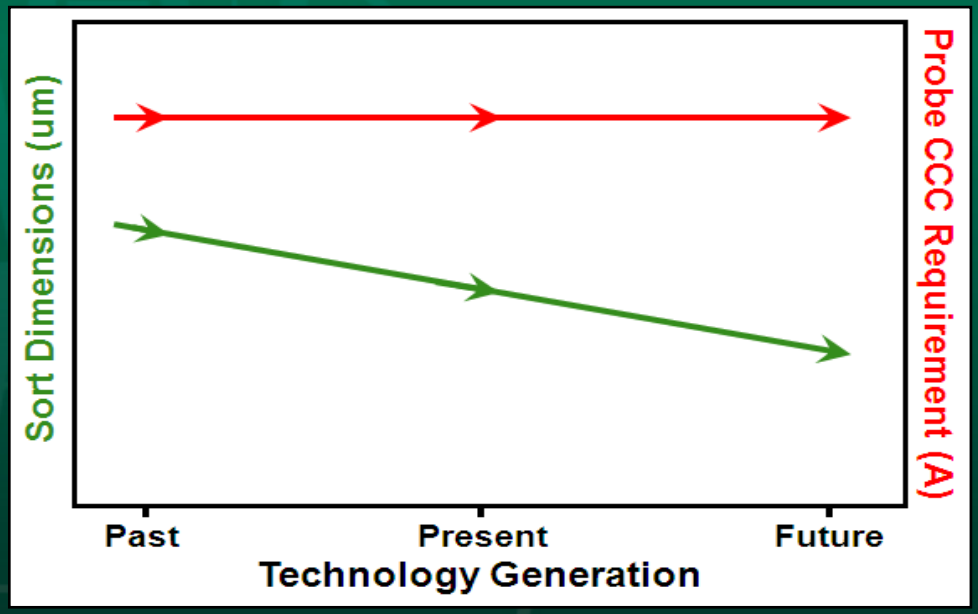
Key Experimental Parameter → Cres

Summary

Background

Sort probe dimensions are reducing to accommodate smaller pitches

Consequently, maintaining sufficient CCC to prevent probe burns becomes increasingly difficult



- Root cause of probe burns often lies in wafer-level defects causing unpredictable surges in current

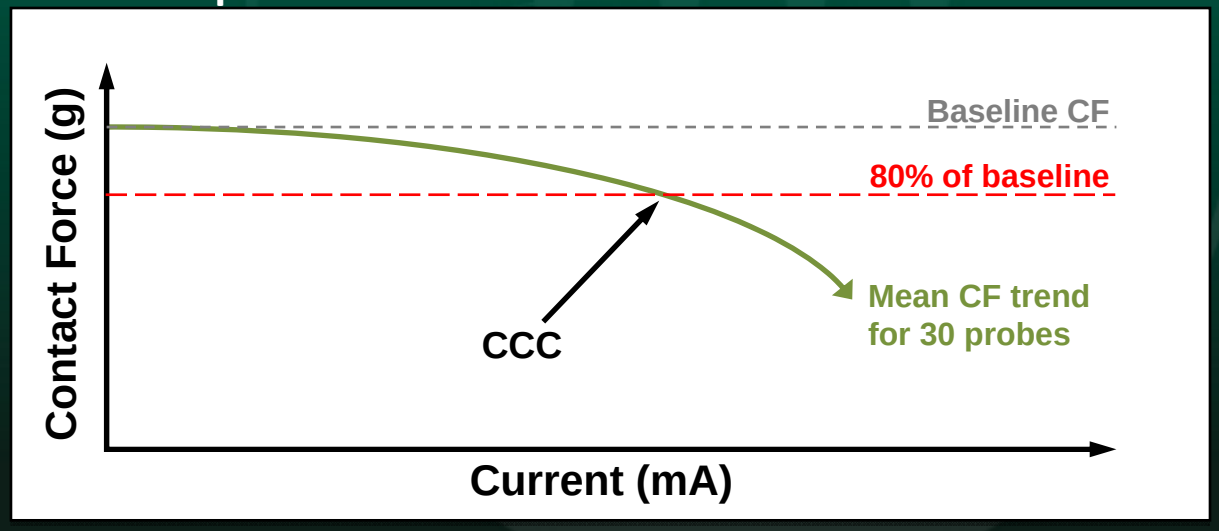
- Characterizing CCC with respect to the dynamic nature of the wafer test environment highlights a probe's robustness under a variety of testing conditions

- A new CCC measurement methodology has been developed with this in mind

International Sematech Manufacturing Initiative (ISMI) Probe Council CCC Measurement Guideline

- **Presented at SWTW in 2009, the goal of the ISMI guideline is** "*…to minimize variability in the measurement of this critical parameter… With a focus on reproducible measurements, this guideline provides CCC ratings that are inherently different from what a user will see in a production environment.*"*

Example of CCC data collected with ISMI Guideline



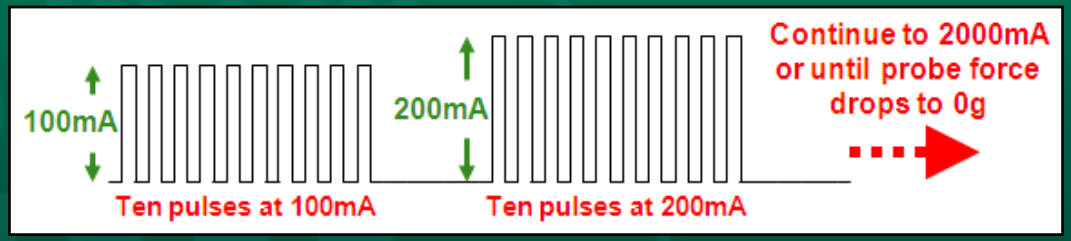
* Daniels, E Boyd, 2009. *ISMI Probe Council Current Carrying Capability Measurement Standard*. San Diego, CA, June 7-10 2009, IEEE SW Test Workshop.

The proposed methodology is NOT a replacement for the ISMI guideline
It is a different methodology meant to better mimic the Intel test environment

New CCC Assessment Methodology

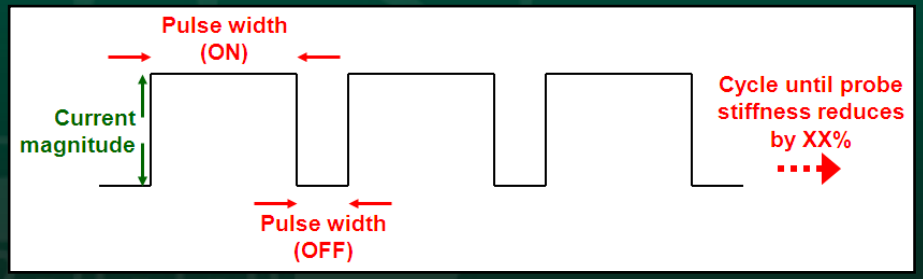
Current Spike CCC Testing

- Highlights susceptibility to transient current effects



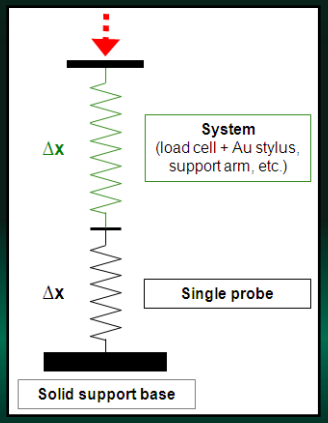
Lifetime Reliability CCC Testing

- Highlights susceptibility to repeated current cycling



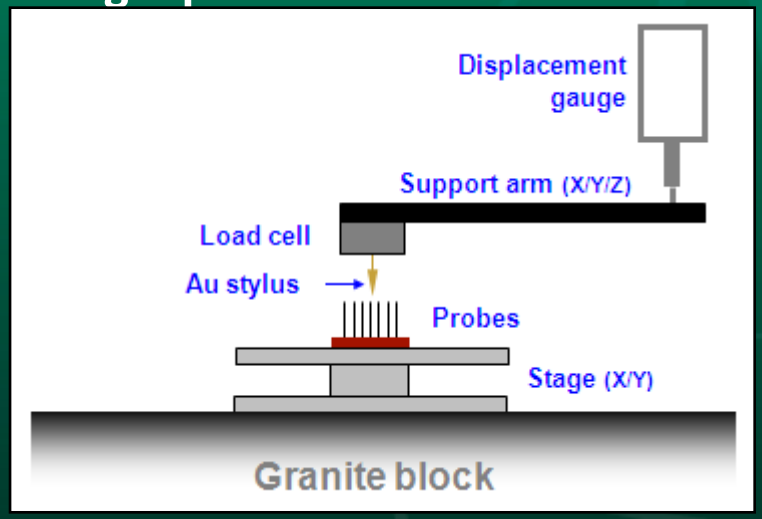
Probe spring constant (k_{probe}) as the CCC metric

- k_{probe} is supplier controlled parameter which is dependent on the probe material and spatial properties
- k_{probe} can be related to a performance metric to determine an appropriate CCC failure criterion



CCC Experimental Setup

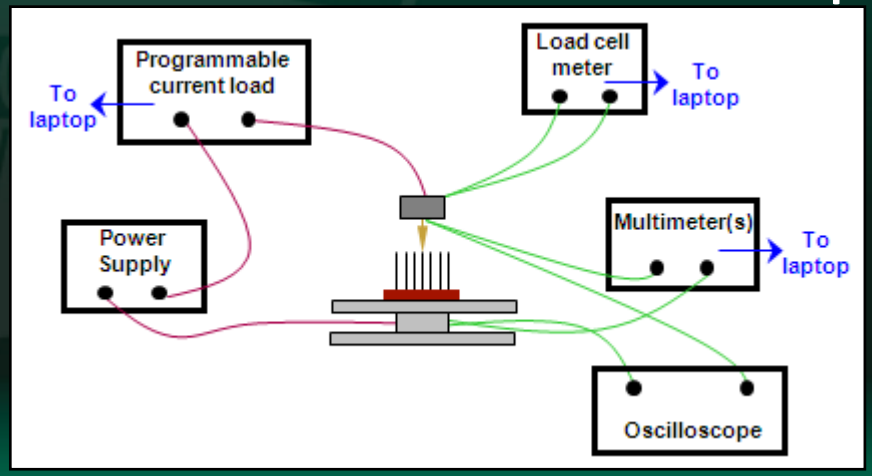
Single probe measurement tool



The single probe measurement tool was built to measure the spring properties of individual Sort probes

The system has been adapted to enable CCC data collection

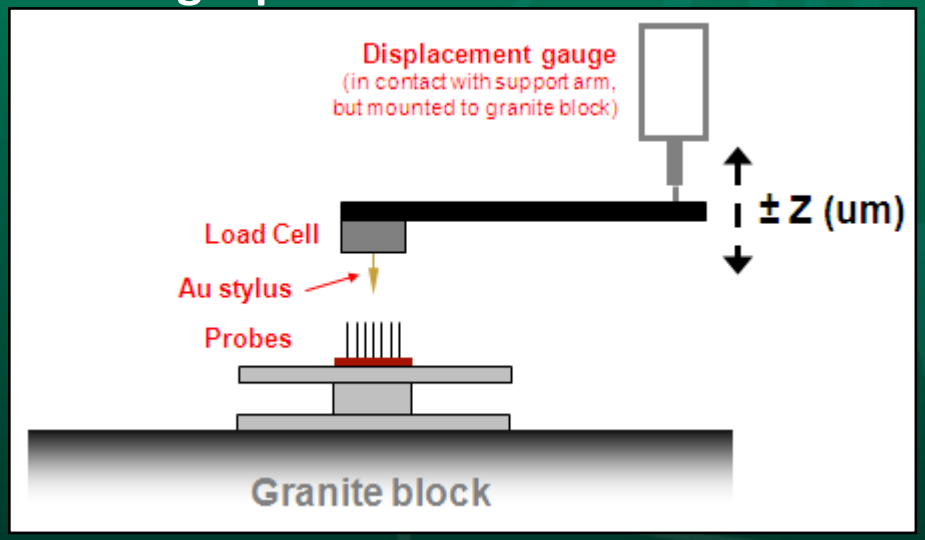
Automated CCC data collection setup

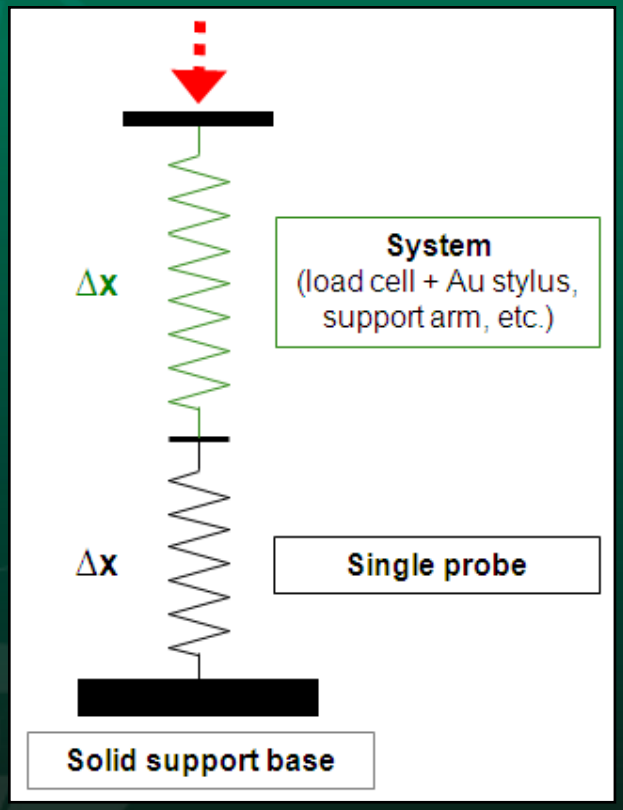


- Programmable current load instrument simulates current draw of the DUT
- Multimeters monitor current and voltage
- Oscilloscope to verify setup functionality
- Custom programming to enable automated start/stop and data logging

Determining k_{probe}

Single probe measurement tool





Hooke's law → $F = -kx$

(F = force, k = spring constant, x = displacement)

Springs in series → $1/k_1 + 1/k_2 + \ldots = 1/k_{total}$ so,

$1/k_{System} + 1/k_{Probe} = 1/k_{Total}$

k_{System} (measured), k_{Probe} (calculated), k_{Total} (measured)

Contact force variation at 100um OT with different system stiffness (if k_{probe} is 0.1g/um):

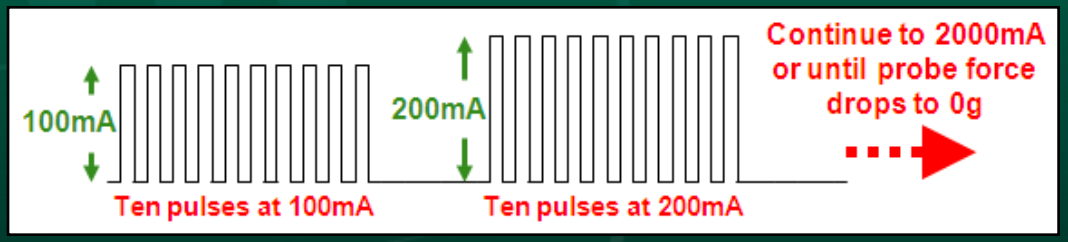
- 7.5g if k_{system} = 0.3g/um
- 8.6g if k_{system} = 0.6g/um

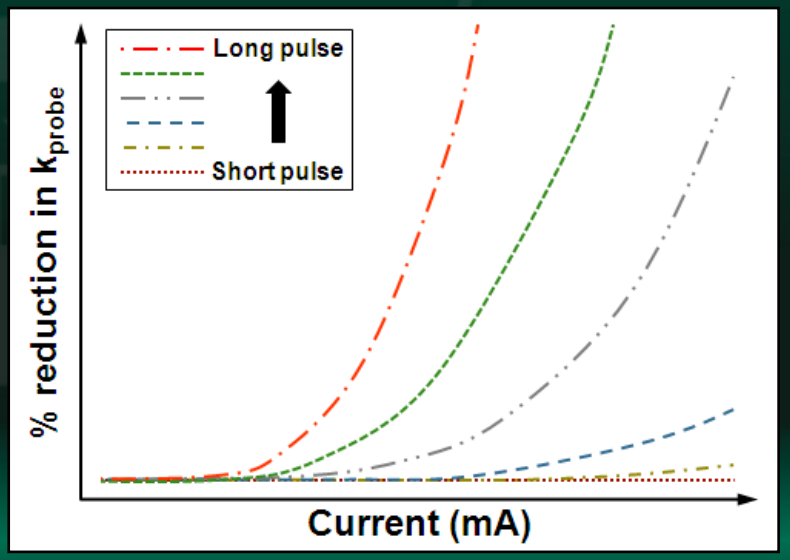
Current Spike CCC Testing

Current Spike testing involves subjecting a probe to short duration current spikes…

- Probe robustness when subjected to transient currents above the ISMI CCC?
- How can limits be set to better protect against probe burns?
- What are the symptoms of a severely burned probe and can it be repaired?
- What are the failure mechanisms of the probe and can they be remedied?
- How do different probe types behave with respect to each other?

Sample DOE Matrix					
Pulse length (msec)	Initial current magnitude (mA)	Final current magnitude (mA)	Current ramp interval (mA)	# of pulses per current magnitude	Time between pulses (msec)
1	100	2000	100	10	1000
10	100	2000	100	10	1000
100	100	2000	100	10	1000
1000	100	2000	100	10	1000

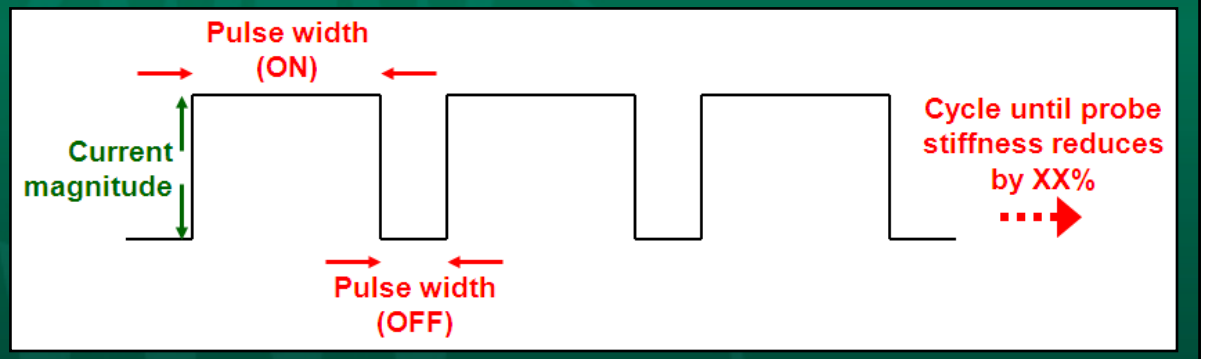


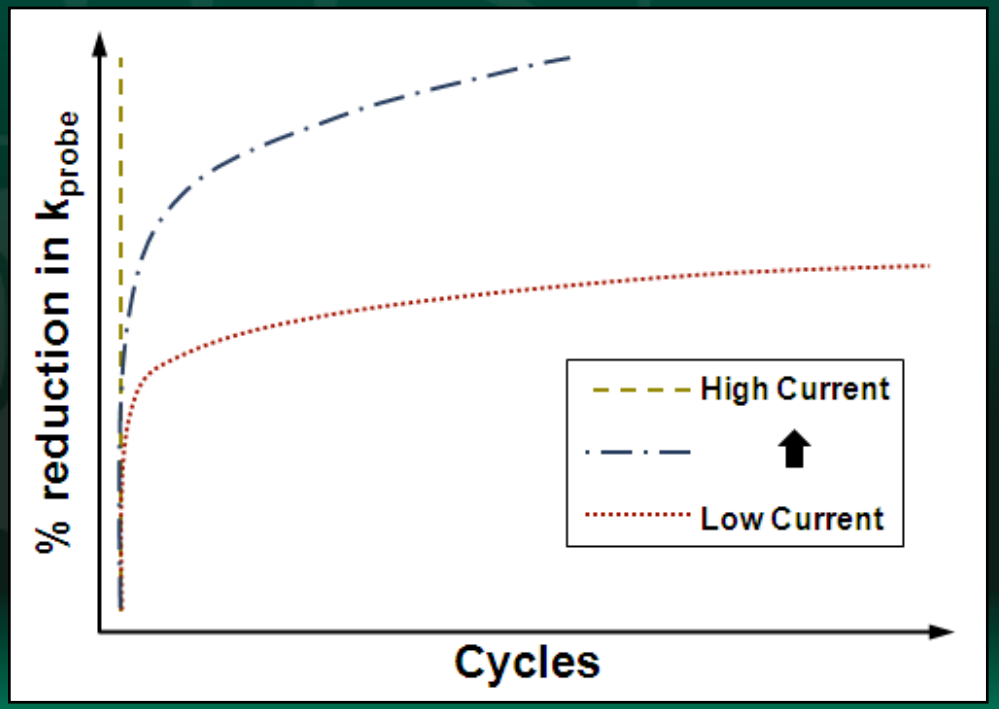


Lifetime Reliability CCC Testing

Lifetime reliability testing indicates the susceptibility of a probe to repeated current cycling…

- At what current magnitude will the probe perform for it's specified lifetime?
- What is the probe failure mechanism when subjected to repeated pulses for an extended period?
- How do environmental factors influence the CCC reliability of the probe over time?

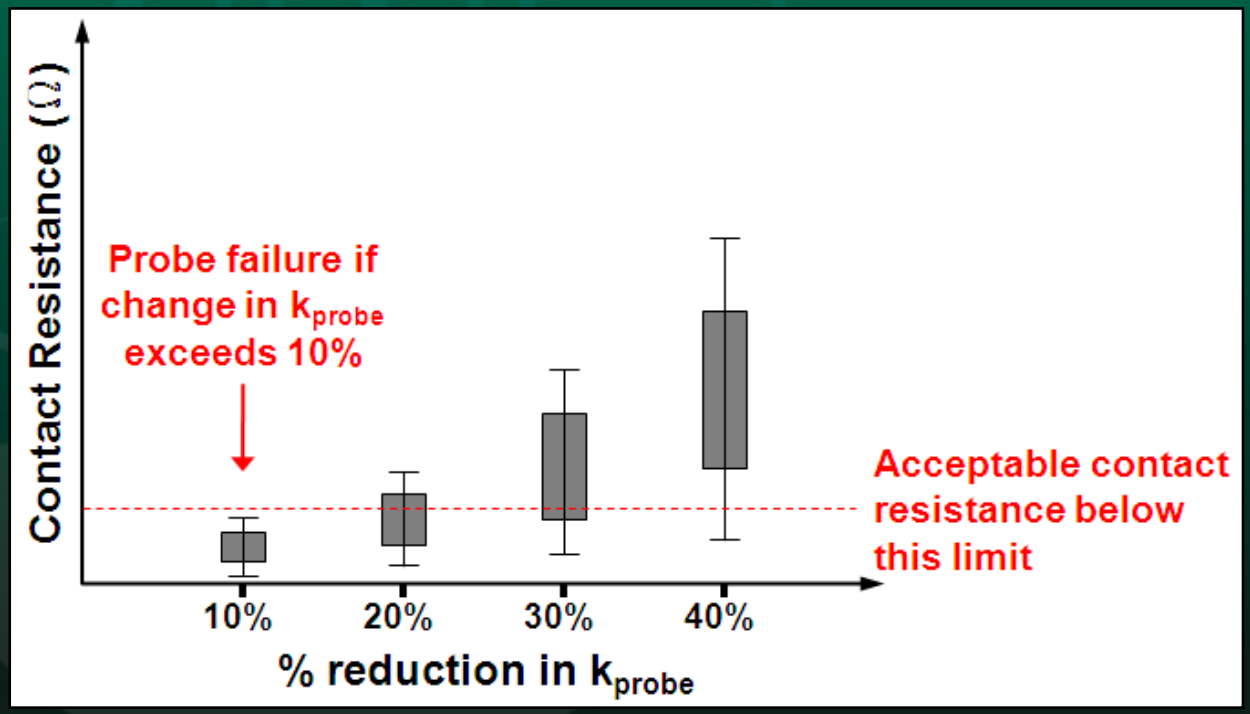




CCC Failure Criterion

A realistic CCC failure criterion should be based on probe performance

- Failure should coincide with the point at which the probe is no longer able to achieve low stable contact resistance
- Thus, CCC failure should be a probe technology dependant metric



Key Parameters → Cres

- Slight changes in Cres have a *significant* impact on the measured CCC of the probe

- Cres variation on the order of 100mΩ has been observed to impact probe lifetime reliability by as much as 10X

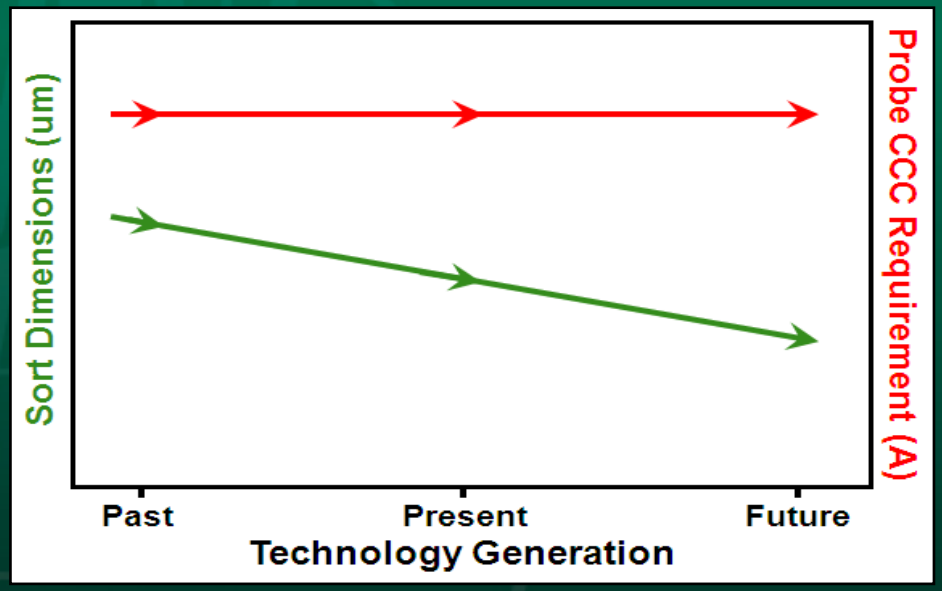
- Heat generation at the probe tip may be the #1 contributing factor to probe failures under current load

- Controlling and understanding the impact of Cres during CCC data collection is paramount

Summary

- Pitch will continue to shrink, and Intel requirements dictate that CCC must NOT follow suit

- Utilizing current spike and lifetime reliability testing will yield valuable information important for assessing and predicting probe behavior



The ISMI Guideline is a good testing methodology, which yields a single metric for comparing probe technologies

Intel requires a more in depth CCC analysis to understand a probe's robustness with respect to our wafer test environment – we are happy to engage with suppliers on understanding and implementing this new methodology