



IEEE SW Test Workshop

Semiconductor Wafer Test Workshop

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Evaluation of New Probe Technology on SnAg and Copper Bumps



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Overview

- **Mobile SoC Trends and Experiment Motivations**
- **Experiment Details**
 - Evaluation Parameters
 - Test Vehicle Setup
- **Evaluation Results**
 - Contact Force vs. Overdrive
 - Probe Marks Comparison
 - Contact Resistance Stability Study
- **Future Work**
 - 20k Pin Probe Card Characterization
- **Summary**



GLOBALFOUNDRIES – Who are we?

Global Manufacturing Operations



Fab 8
Future leading-edge
300mm manufacturing
Saratoga County, NY



Fab 1
Leading-edge 300mm
manufacturing campus
Dresden, Germany



Fab 2, 3, 3e, 5, 6
Mainstream 200mm
manufacturing campus
Woodlands, Singapore
Tampines, Singapore



Fab 7
Mainstream 300mm
manufacturing campus
Woodlands, Singapore



Mobile SoC Trends and Experiment Motivations

- **Mobile SoC Technology Trends**

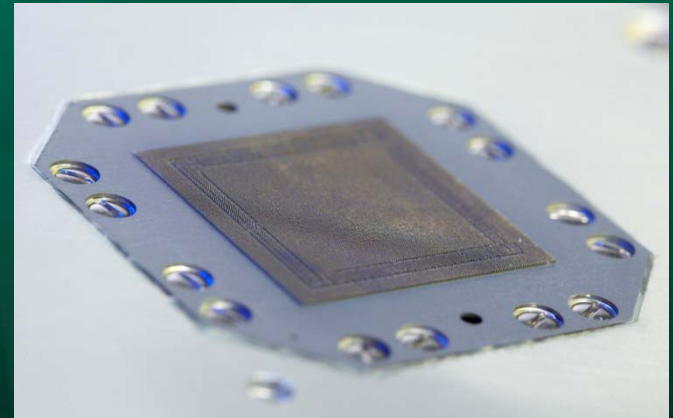
Mobile SoC IC Trends	Probe Card Design Considerations
Low-power mobile SoC feature INTEGRATION	More Probes per DUT, X000 probes, at smaller pitch ($= < 130\mu\text{m}$ pitch)
COST-DOWN pressure	Multi-DUT, X8-X16 DUTs
LEAD-FREE to comply with RoHS mandate	SnAg bumps, Copper pillars

- **Evaluate MicroProbe's Mx Vertical MEMS Technology**
 - Low-force MEMS probe card to support 20-30k pin cards
 - Support SnAg and Copper packaging materials



MicroProbe Mx-Flipchip Overview

- Vertical MEMS Architecture
- Multi-DUT capable
- Low probe force: 2-5 g
- Ultra high pin count: >20k
- Application-specific Probe Design for advanced packages
 - Optimal Probe Shape for Pitch & Force
 - Specific Metallurgy for Best Contact
 - Replaceable Probes

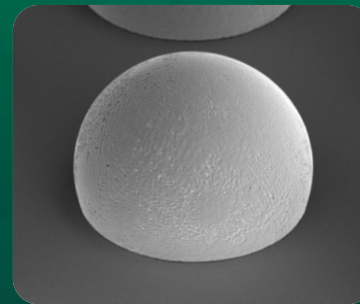


Experiment Details

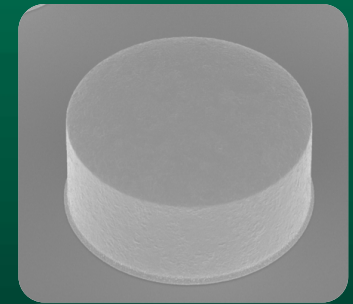
Evaluation Parameters

- **Two Packaging Types**

- SnAg Bumps
- Copper Pillars



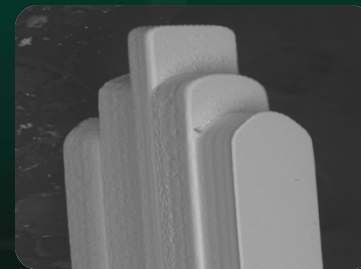
SnAg Bump



Cu Pillar

- **Two Mx-Flipchip Vertical MEMS Probes**

- Mx-150a: Tip Design 1, Metallurgy 1
- Mx-150b: Tip Design 2, Metallurgy 2



Mx-150a

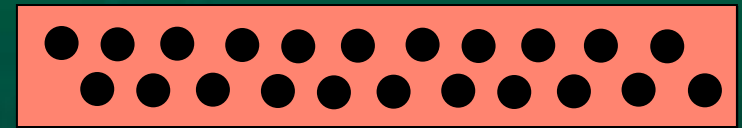
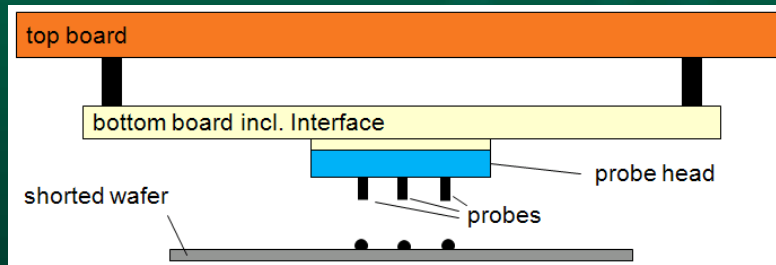


Mx-150b

Experiment Details

Test Vehicle Setup

- Two 22-pin test vehicles were used to evaluate Mx technology



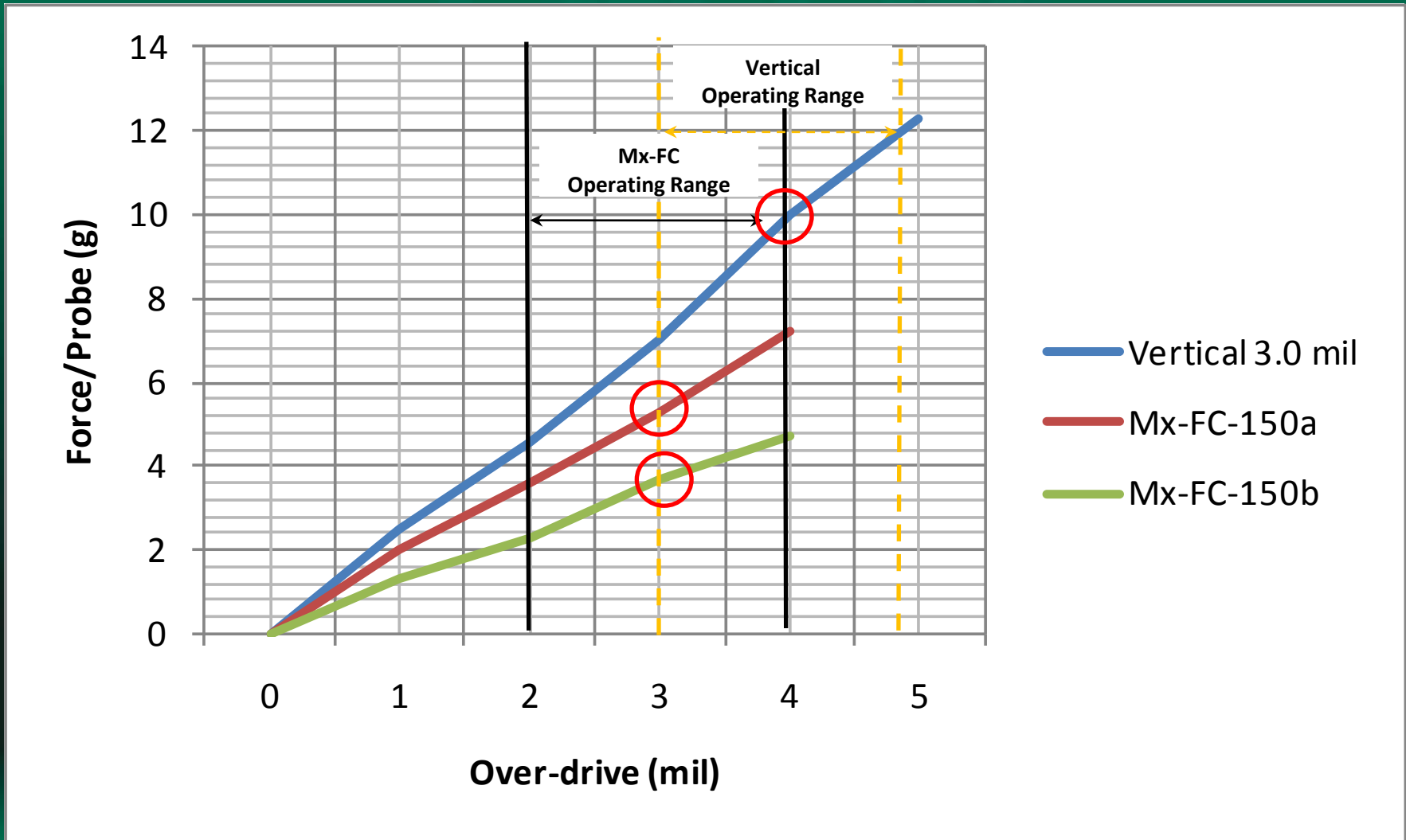
Probe Layout

- **Test Procedure:**

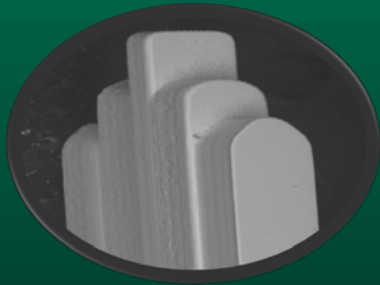
- A defined current is forced and the contact resistance is calculated using the voltage measured
- Probes are triggered in a serial mode and the remaining probes are set to GND
- The measurements have been done on a shorted wafer

Probe Force vs. Overdrive

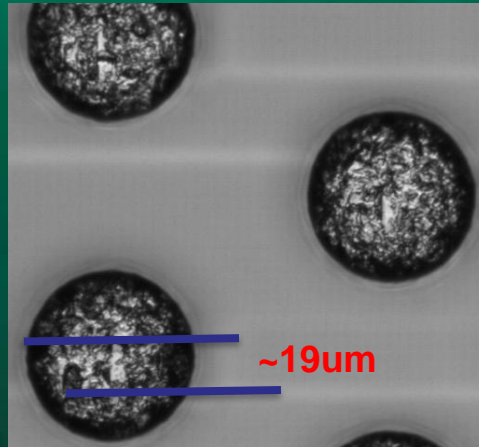
Mx-FC Probe Force is <50% of Vertical 3.0 mil @ 150um pitch



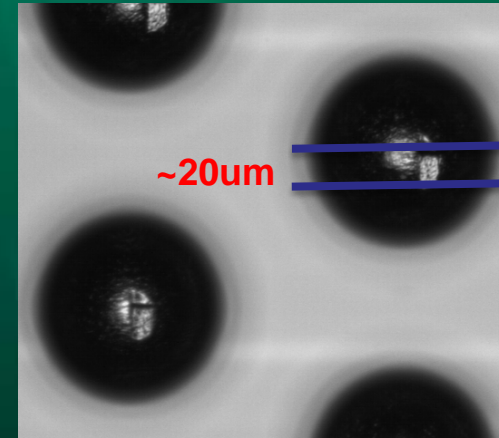
Probe Mark Comparison



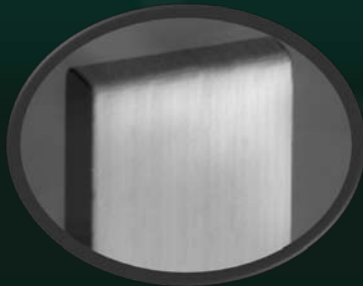
Mx-FC-150a



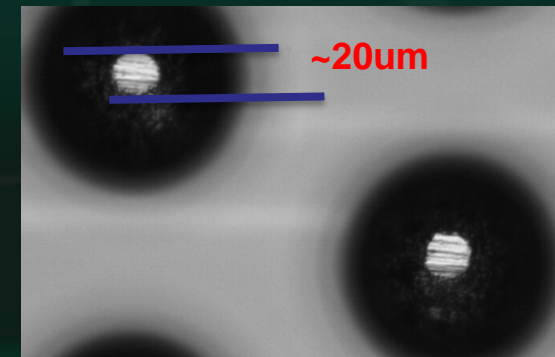
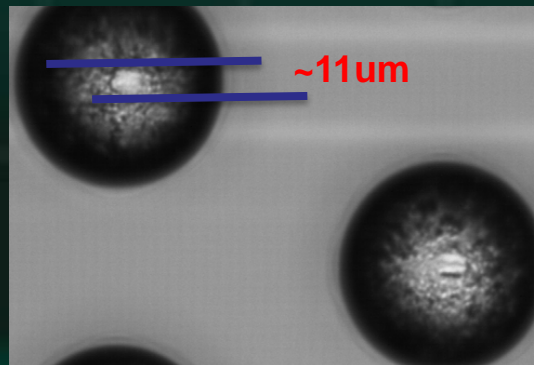
Copper Pillars



SnAg Bumps

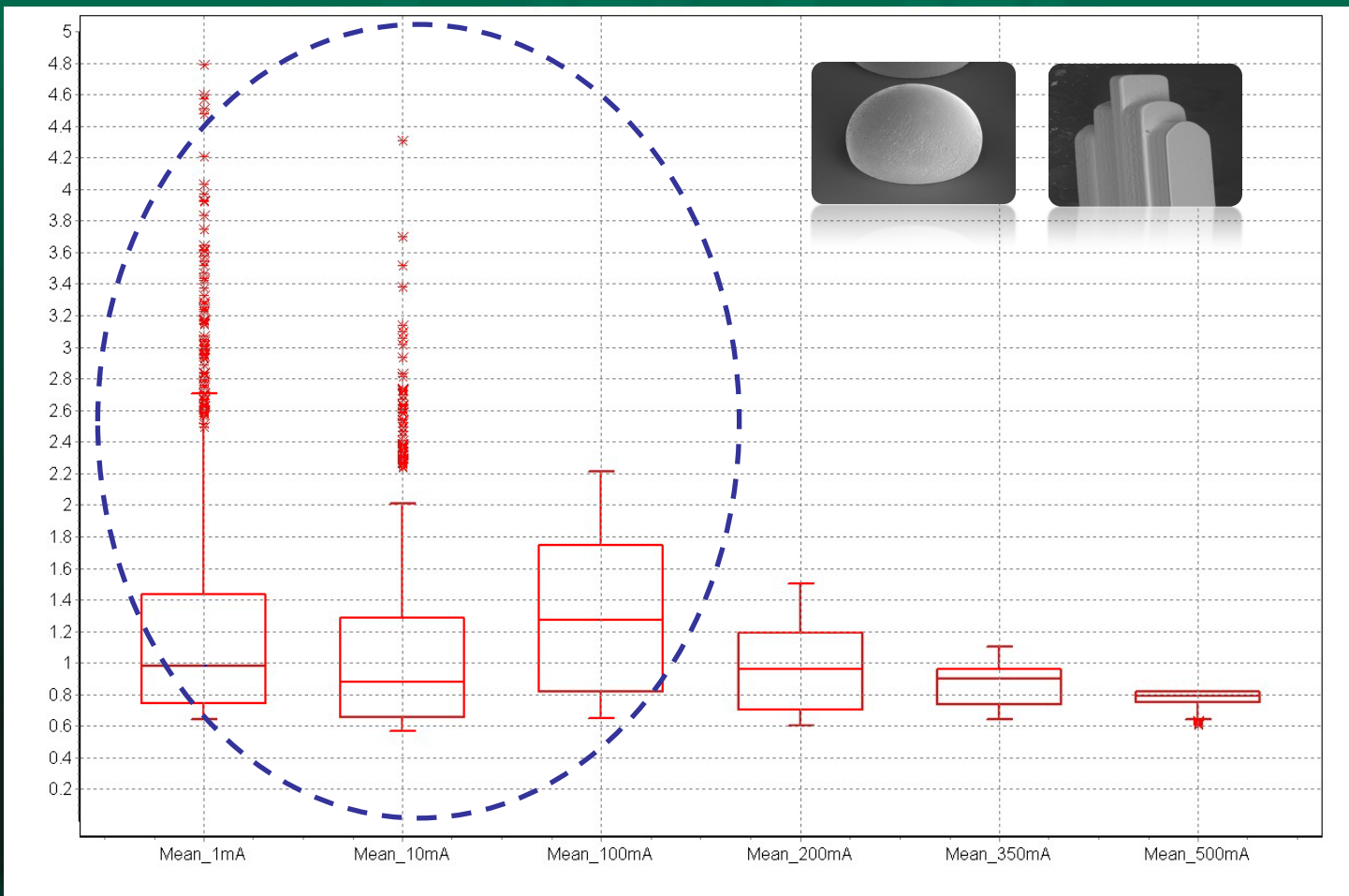


Mx-FC-150b



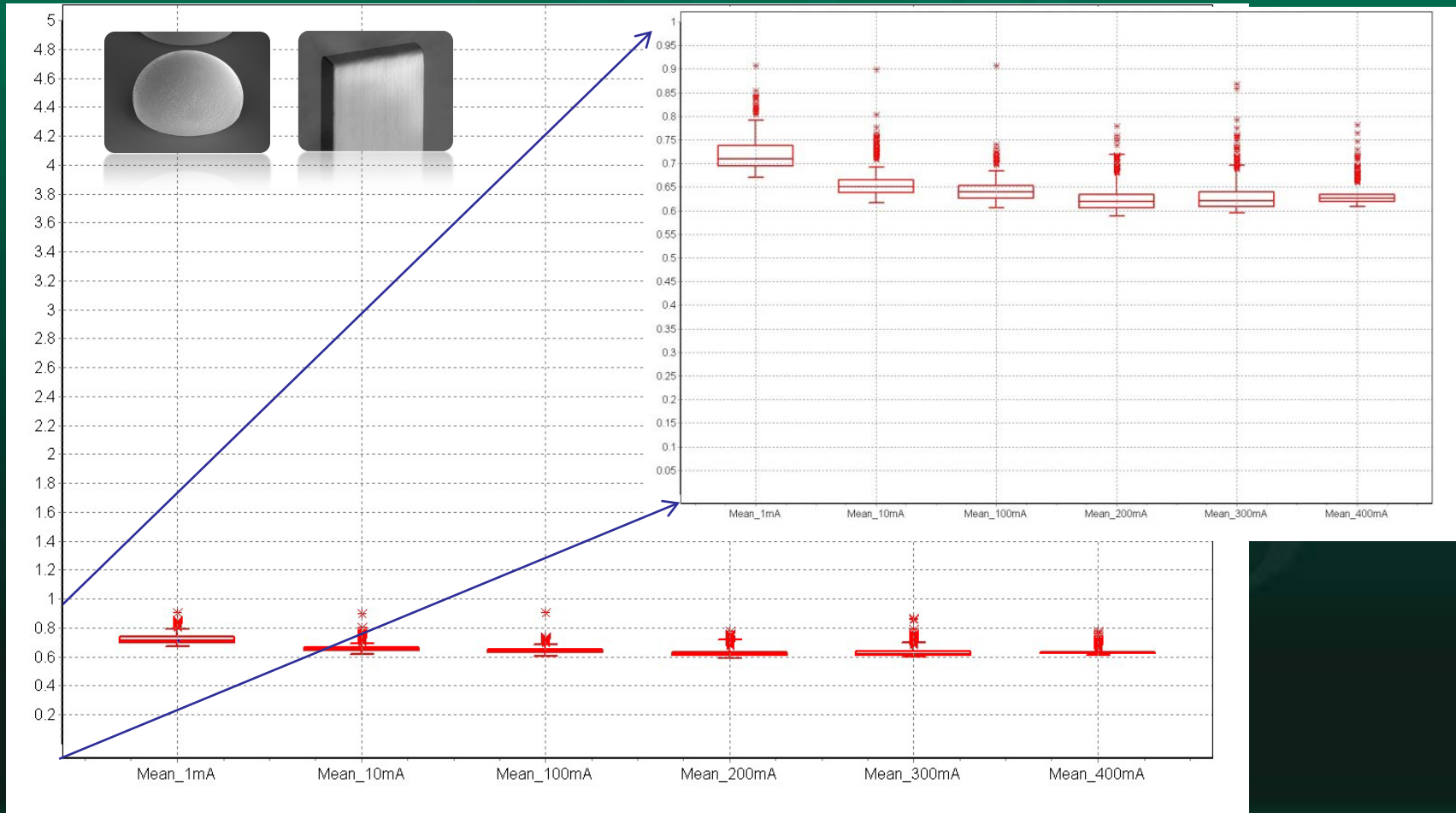
Mx-FC-150a on SnAg Bumps

Contact Resistance Scatters at Lower Currents



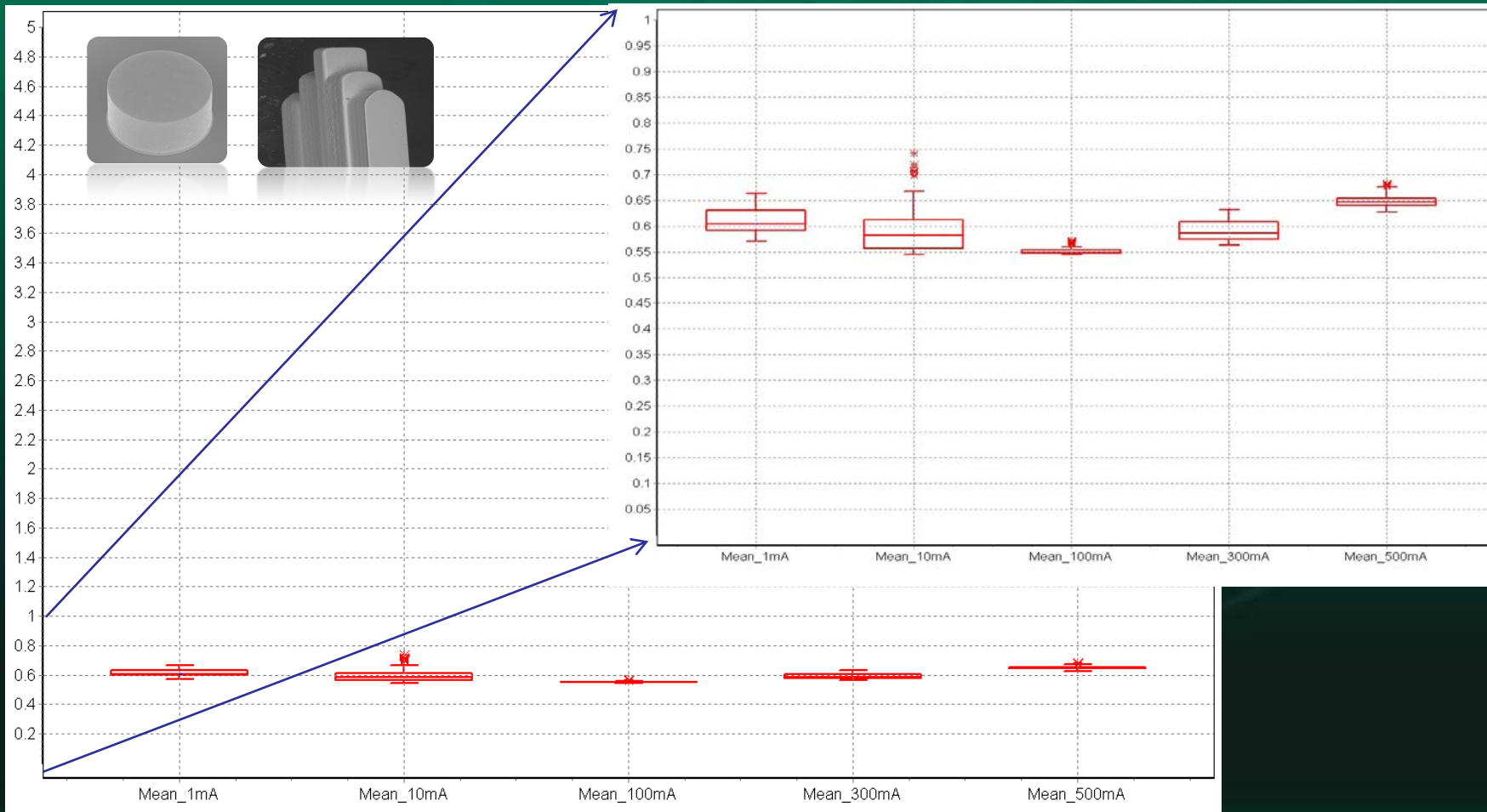
Mx-FC-150b on SnAg Bumps

Stable Contact Resistance Measured At Various Currents



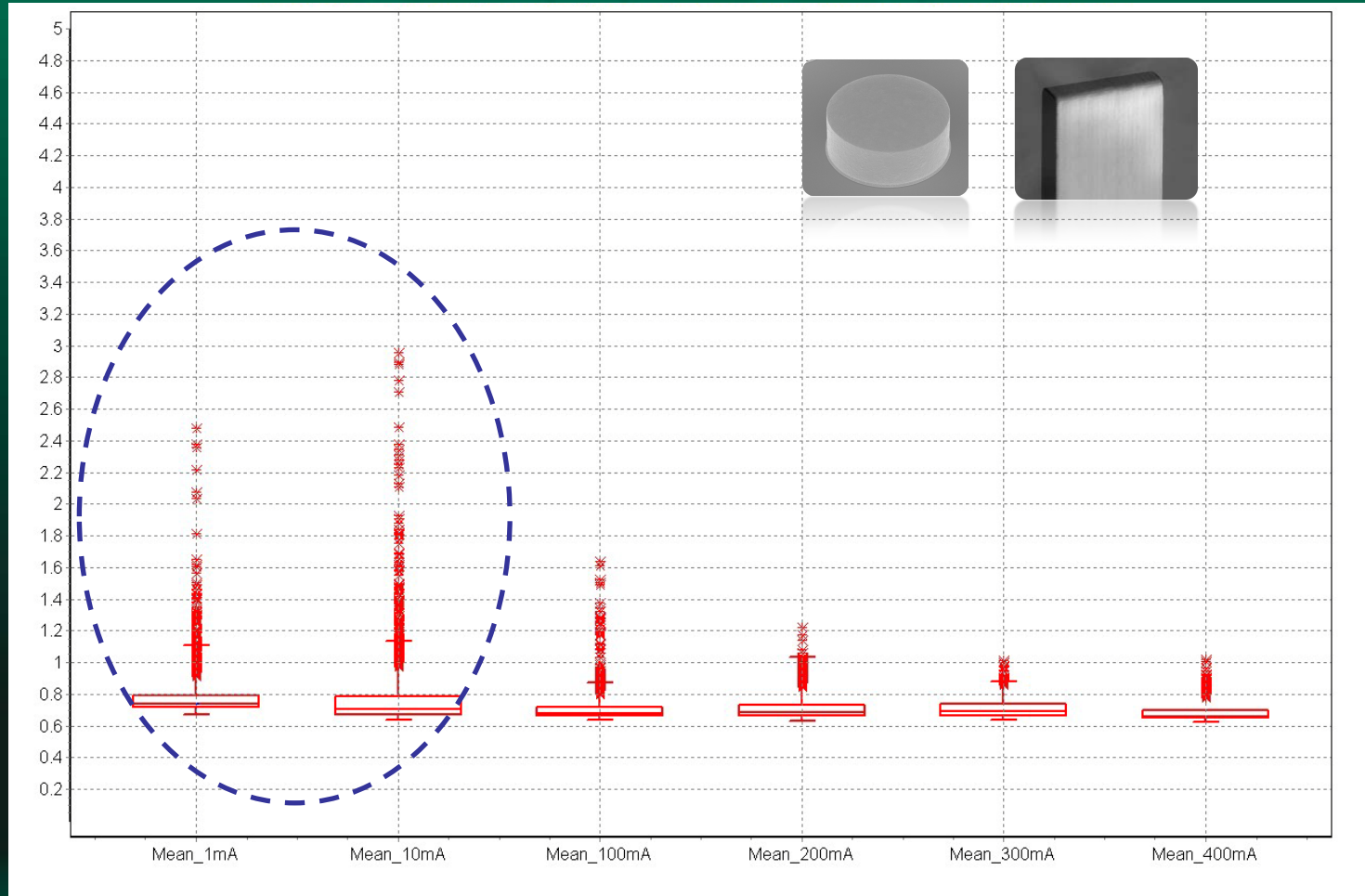
Mx-FC-150a on Copper Pillar

Stable Contact Resistance Measured At Various Currents

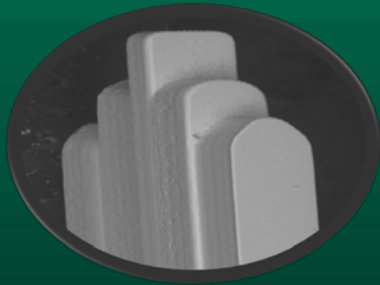


Mx-FC-150b on Copper Pillars

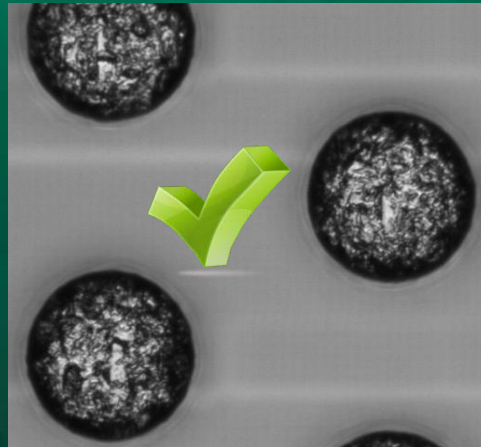
Contact Resistance Scatters at Lower Currents



Optimal Probe Configuration Selected

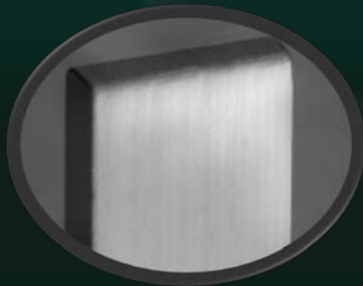


Mx-FC-150a

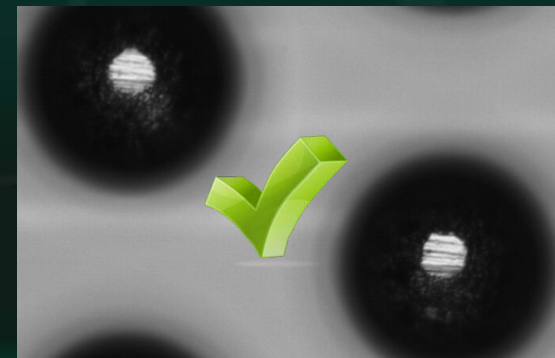


Copper Pillars

SnAg Bumps



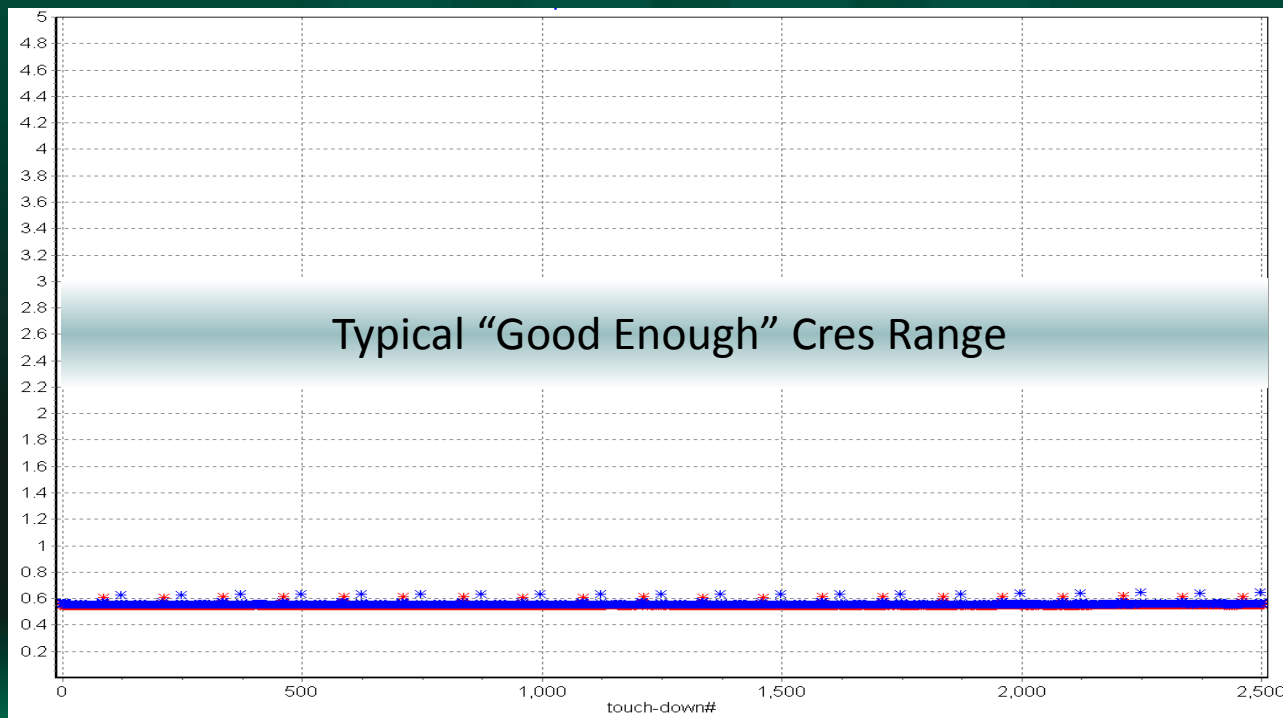
Mx-FC-150b



Mx-150a on Copper Pillars

Stable Contact Resistance over 2500 TD Test

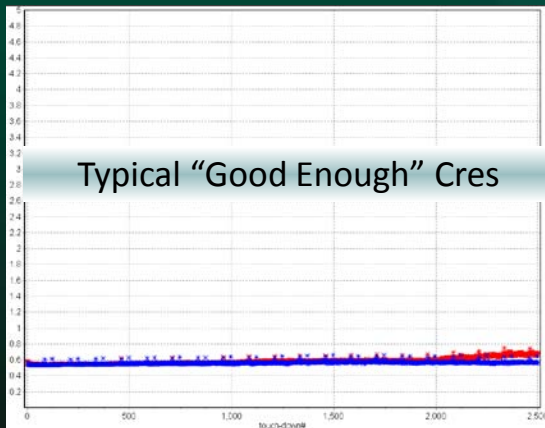
- **Current Setting: 100mA**
- **Cleaning Frequency: 250 TD on-line cleaning**
- **Cleaning Setting: 25um OD in z-only; 10 TD**
- **Cleaning Media: 1um lapping film (3M)**



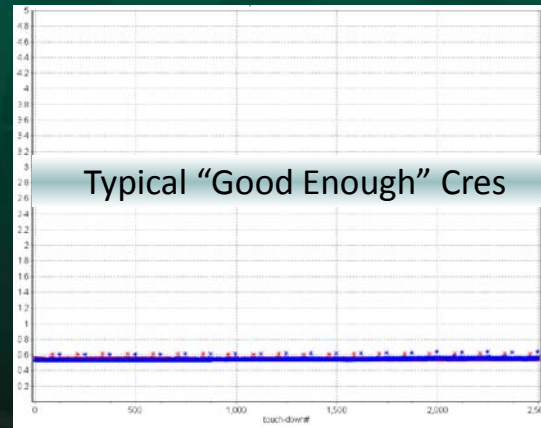
Mx-FC-150a on Copper Pillars

Cleaning Recipe can be Further Optimized for Various Currents

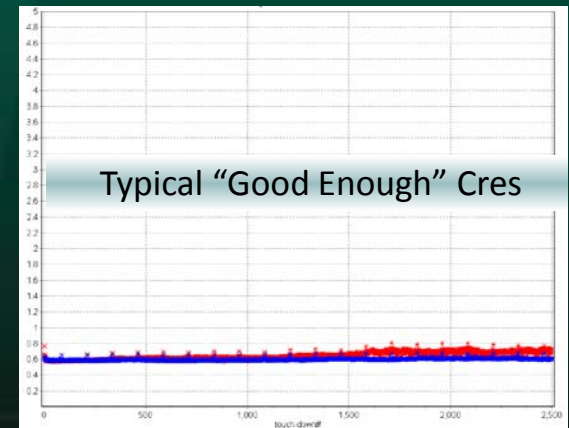
- **Cleaning Frequency: 250 TD on-line cleaning**
- **Cleaning Setting: 25um OD in z-only; 10 TD**
- **Cleaning Media: 1um lapping film (3M)**



10mA



100mA

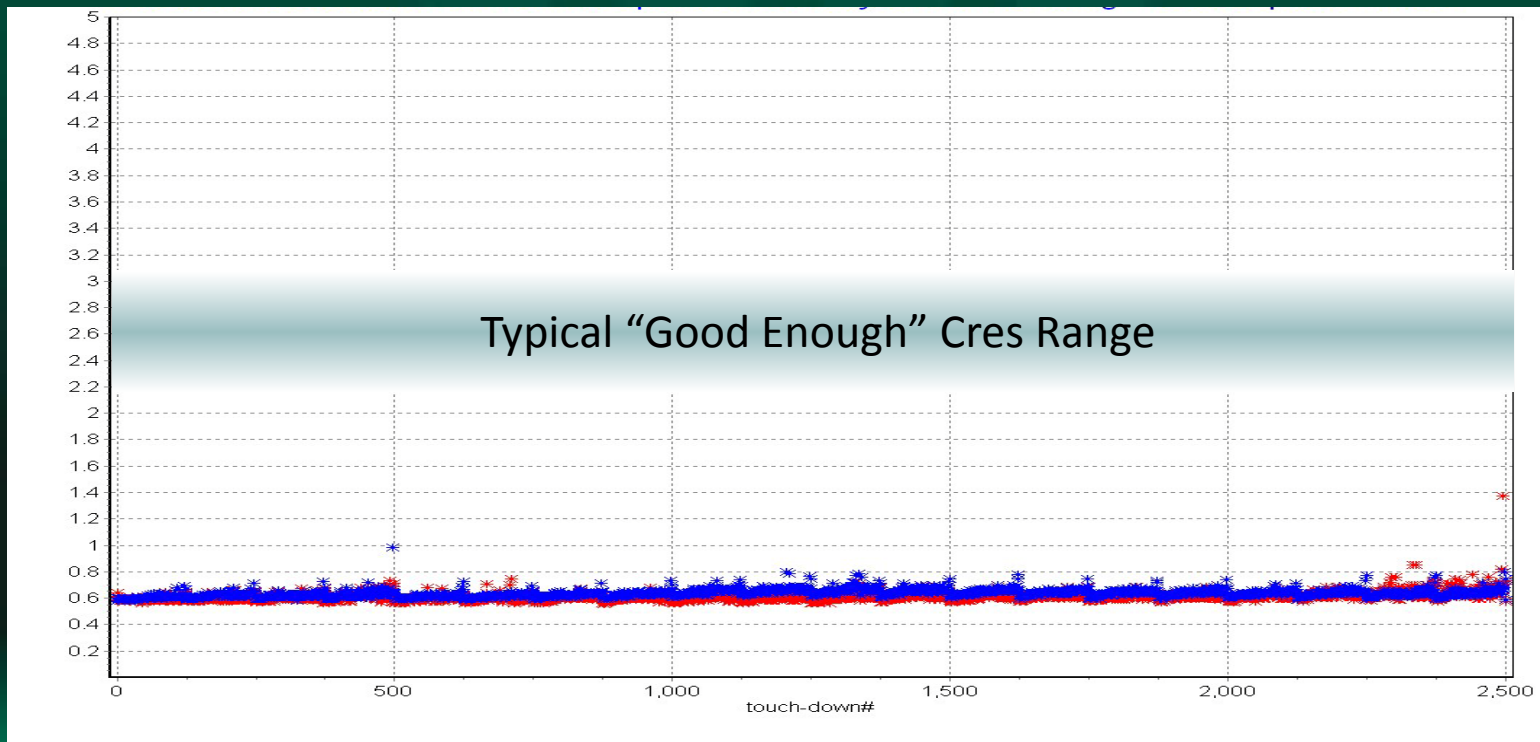


300mA

Mx-150b on SnAg Bumps

Stable Contact Resistance over 2500 TD Test

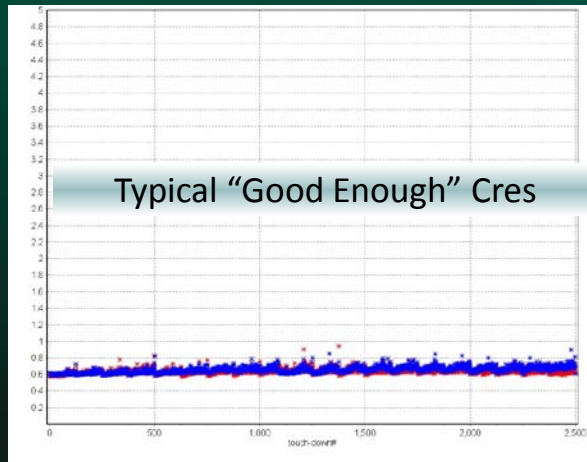
- Current Setting: 100mA
- Cleaning Frequency: 250 TD on-line cleaning
- Cleaning Setting: 25um OD in z-only; 10 TD
- Cleaning Media: 1um lapping film (3M)



Mx-FC-150b on SnAg Bumps

Stable Cres at Various Current Settings

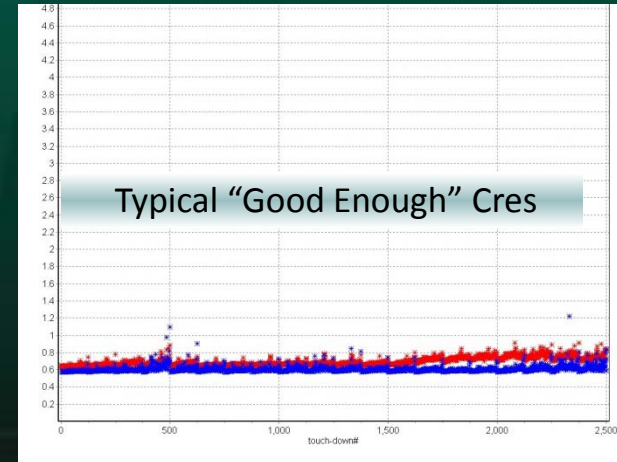
- **Cleaning Frequency: 250 TD on-line cleaning**
- **Cleaning Setting: 25um OD in z-only; 10 TD**
- **Cleaning Media: 1um lapping film (3M)**



10mA



100mA



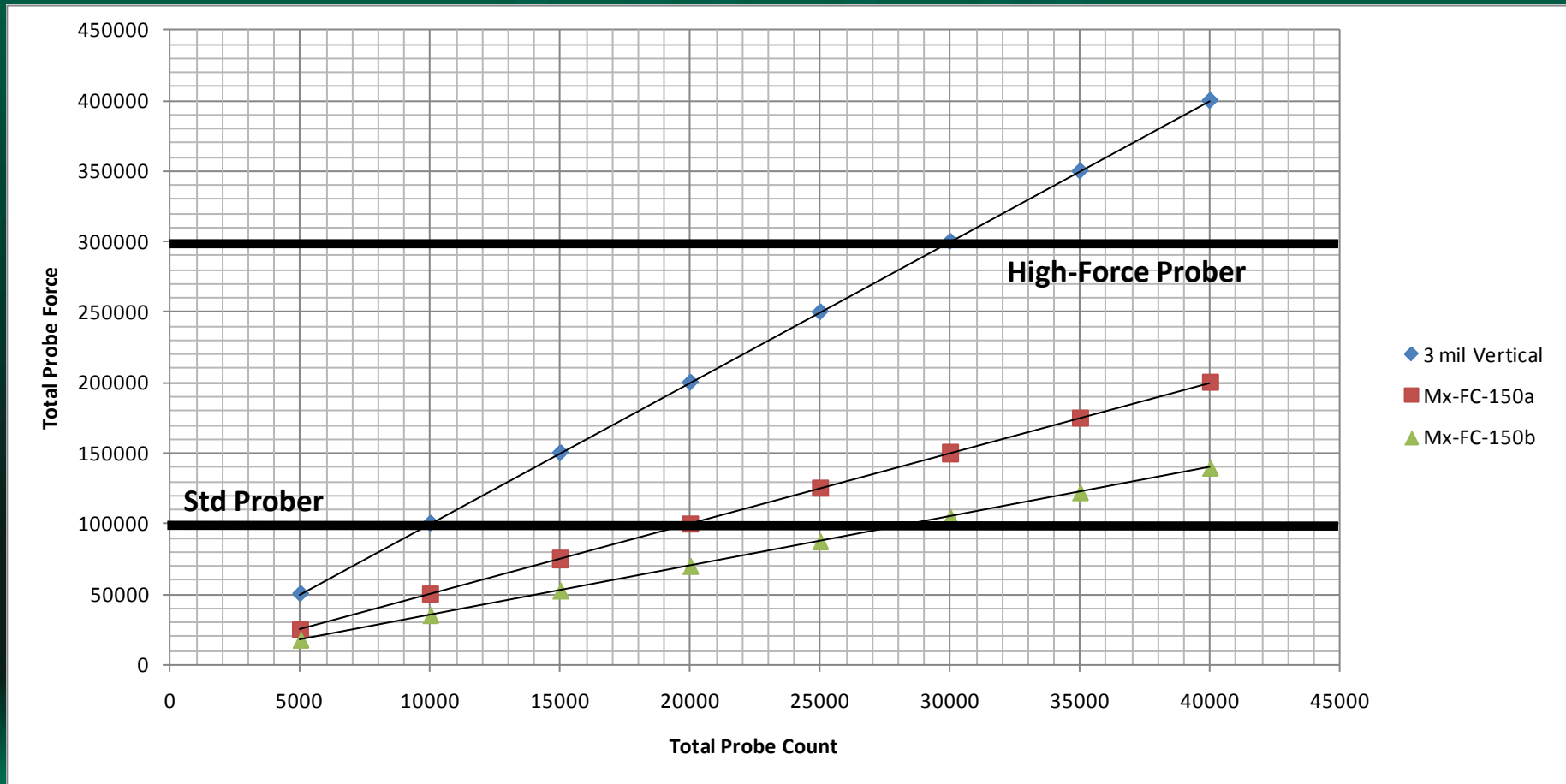
300mA



Future Work: >20k Pin Probe Card Characterization

Low Force Mx-FC Probes Enable High Probe Counts and Multi-DUT

- At 100kg limit of a standard prober, low-force Mx-FC-150a and Mx-FC-150b allow maximum probe count of >20,000 probes/card



Future Work: >20k Pin Probe Card Characterization

Mx shows <50% z-deflection => Better lifetime and product stability

Mx: Vertical MEMS

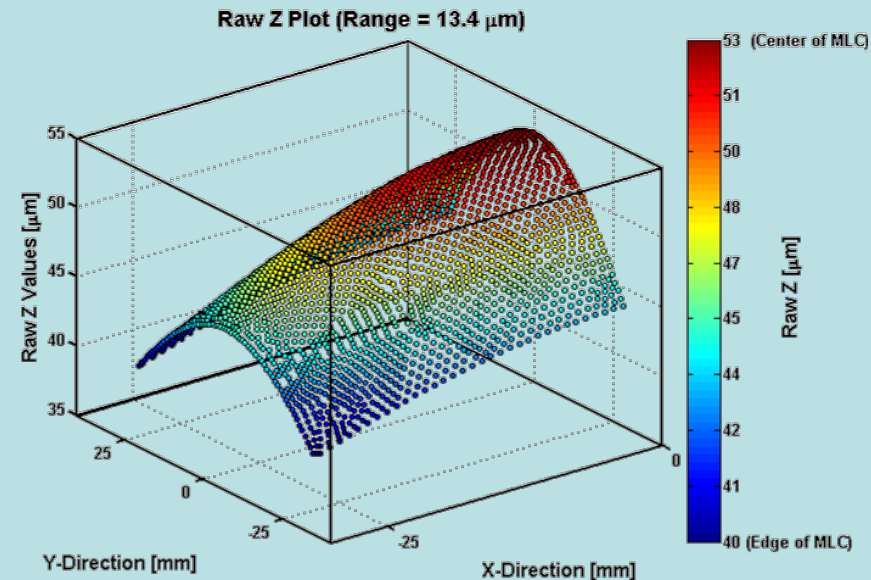
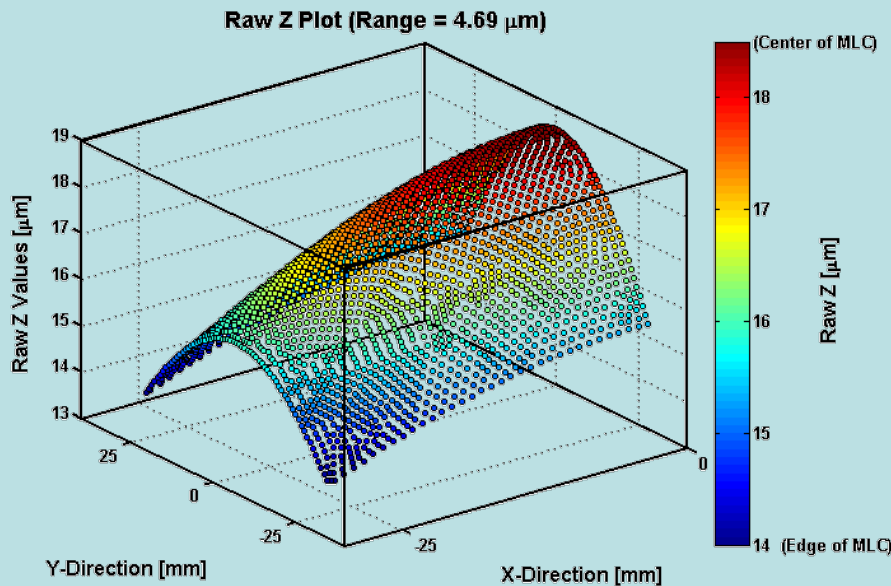
Probe Force = 3.5 g/probe

Z-deflection = 19 μm

Cobra-style Vertical

Probe Force = 10 g/probe

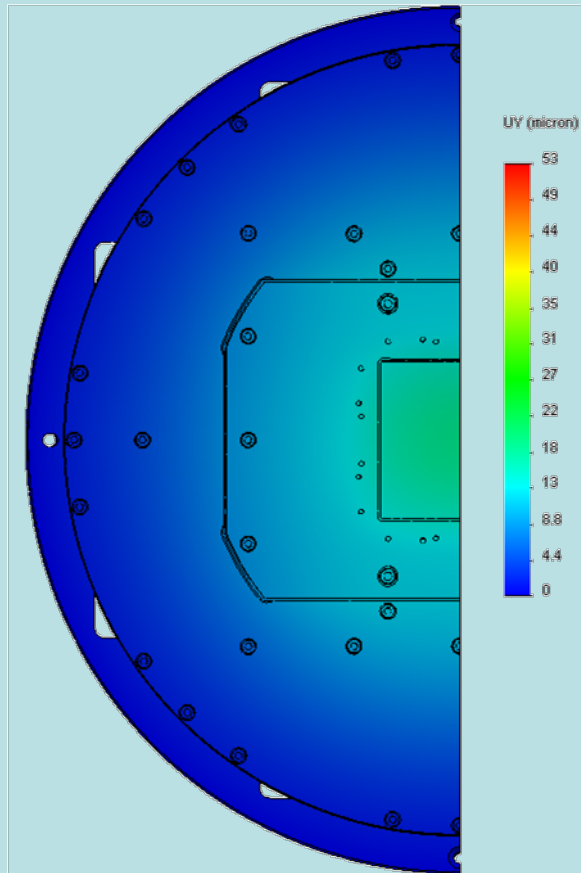
Z-deflection = 53 μm



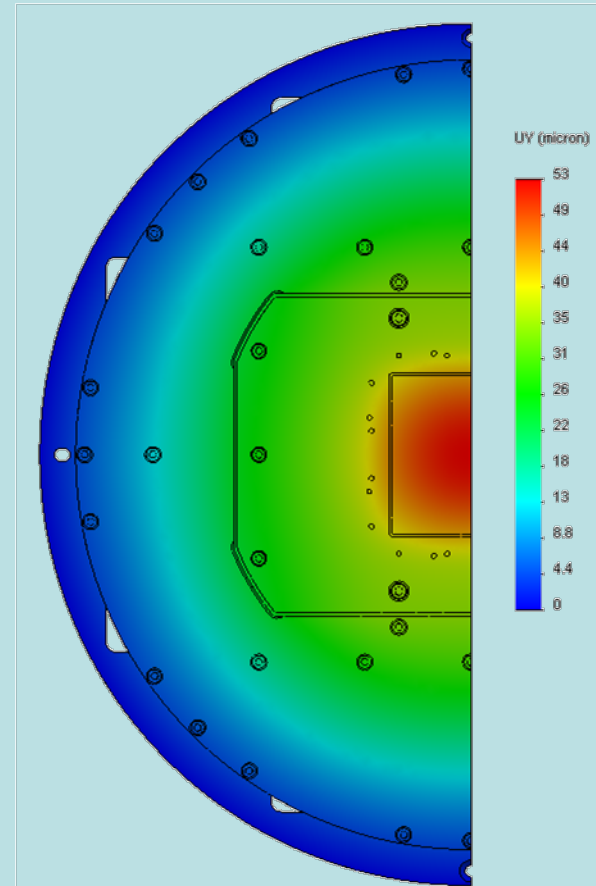
Future Work: >20k Pin Probe Card Characterization

Displacement in Probe Load Direction: Mx shows <50% z-deflection

Mx Vertical MEMS Probe Card



Cobra-style Vertical Probe Card



Summary

- **Freedom to choose metallurgy and probe design allows contact optimization for different bump materials**
 - Mx-FC-150a (Tip 1 + PM1) showed good Cres for Cu pillars
 - Mx-FC-150b (Tip 2 + PM2) showed good Cres for SnAg bumps
- **Low-force Mx-FC architecture offers scalability in ultra-high pin count and finer pitch**
 - At 100kg limit of existing prober install base, Mx-FC enables 20-30k probes
 - Less z-deflection for better probe card lifetime and stability
- **Future work**
 - >20k pin count probe card performance/lifetime characterization



Acknowledgement

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 - Mike Slessor
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