SWTEST

PROBE TODAY, FOR TOMORROW

IBM Low Force Rigid Probe Technology

Grant Wagner

David Audette

Test Hardware Development Engineers

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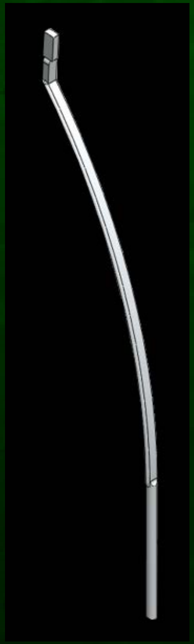
Agenda

- History
- Objective
- Front End Hardware Stack
- Low Force Probe Structure
- C4 Contact
- Design Features
- Summary

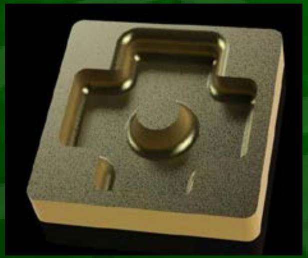
IBM History of Rigid Probing

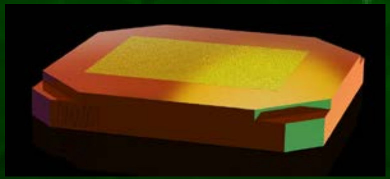
2000		2010	2015	2018	2020
Force per pin	16-18 g	11-13 g	11-13 g	6-7 g	

< 2000
Cobra

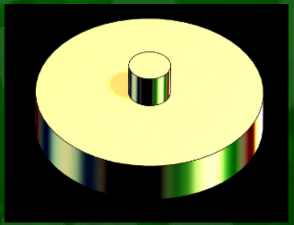


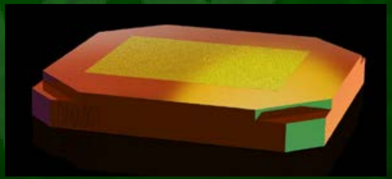
2000-2012
TFI



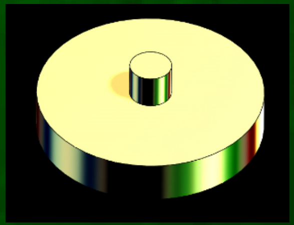


2012-2015
Probe-on-Ceramic

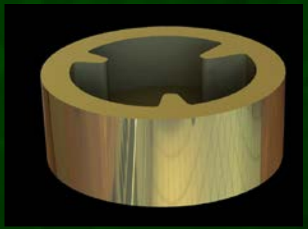




2015-2018
Probe-on-Organic



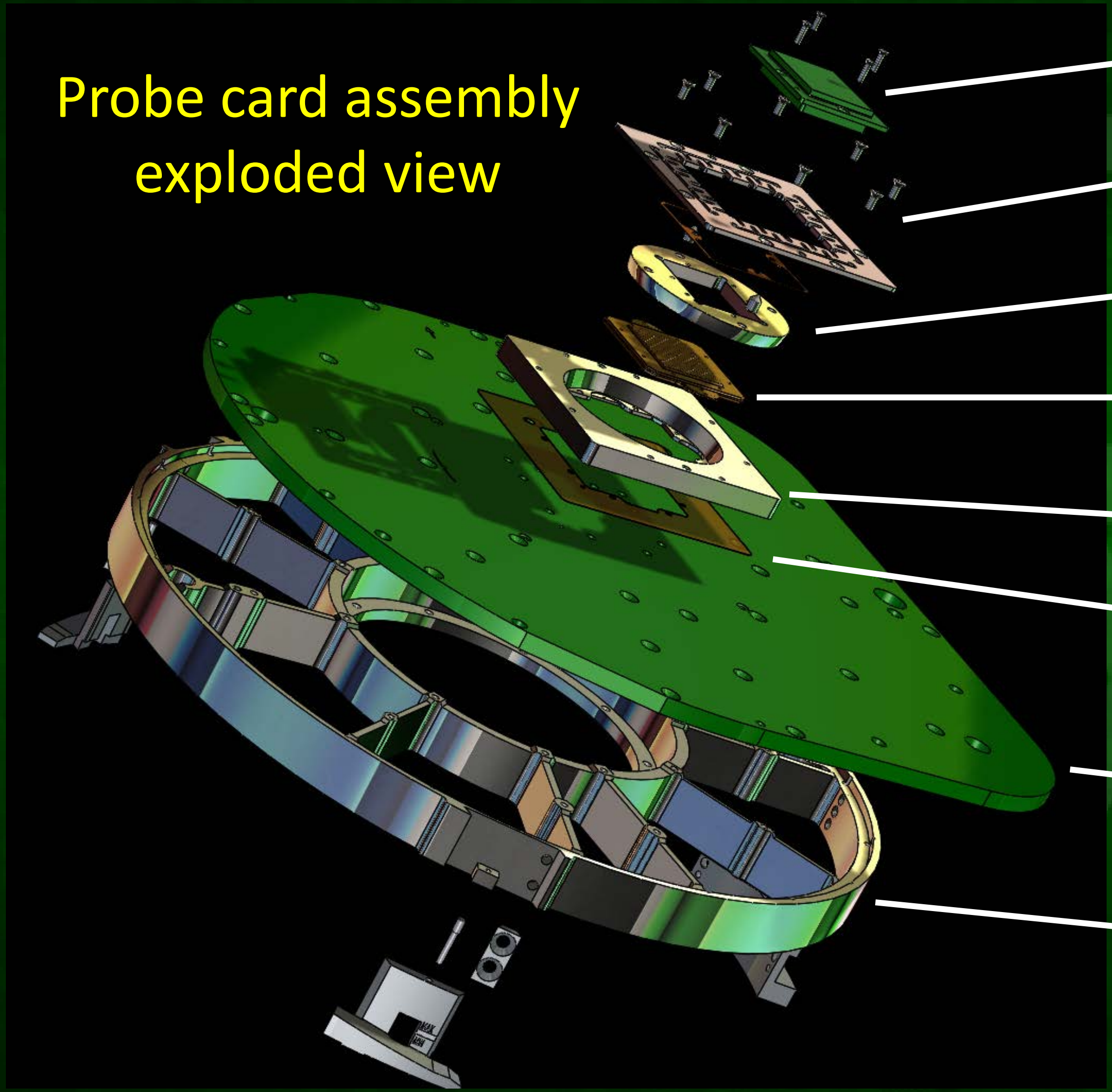
2018 <
LFP



Objective

Design a low cost, low force wafer test probe for large chip, high pin count, high power server applications

Wafer Probe FEH Stack Up



Low Force Probe

Spring Plate

Inner Bearing

Interposer

Base Bearing

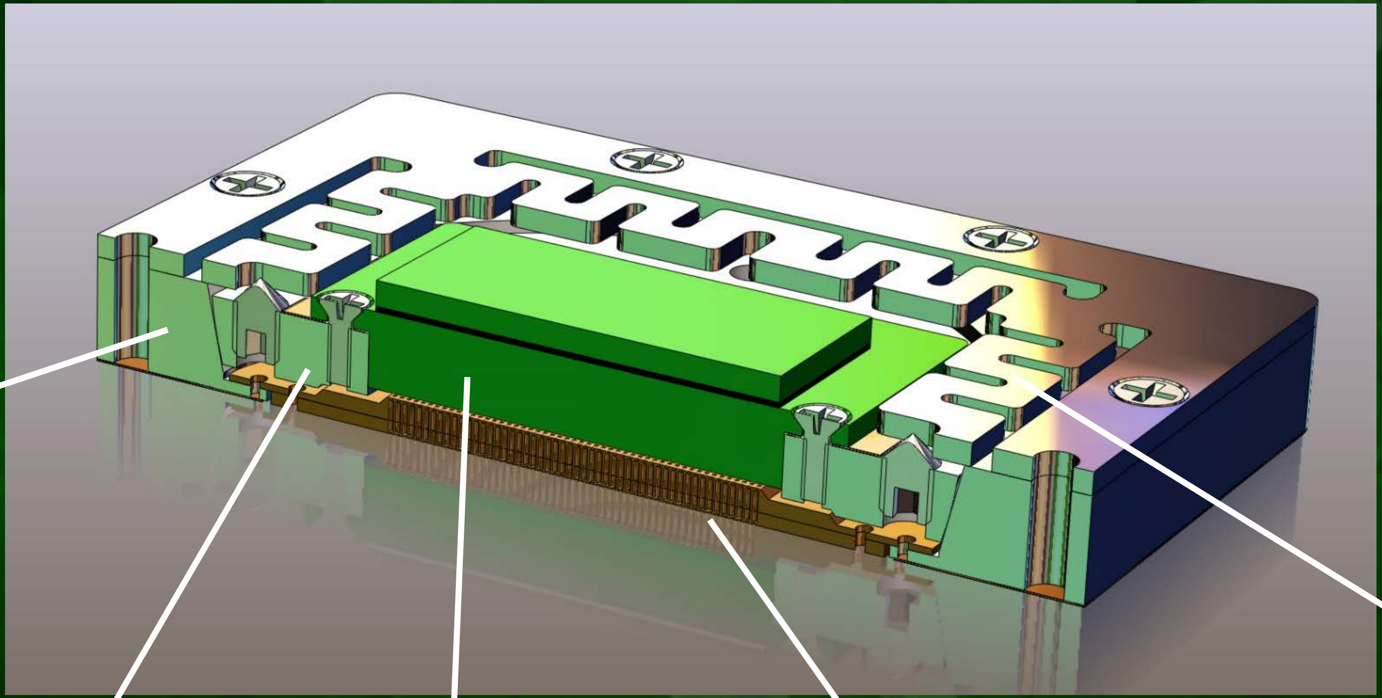
Insulator

PCB

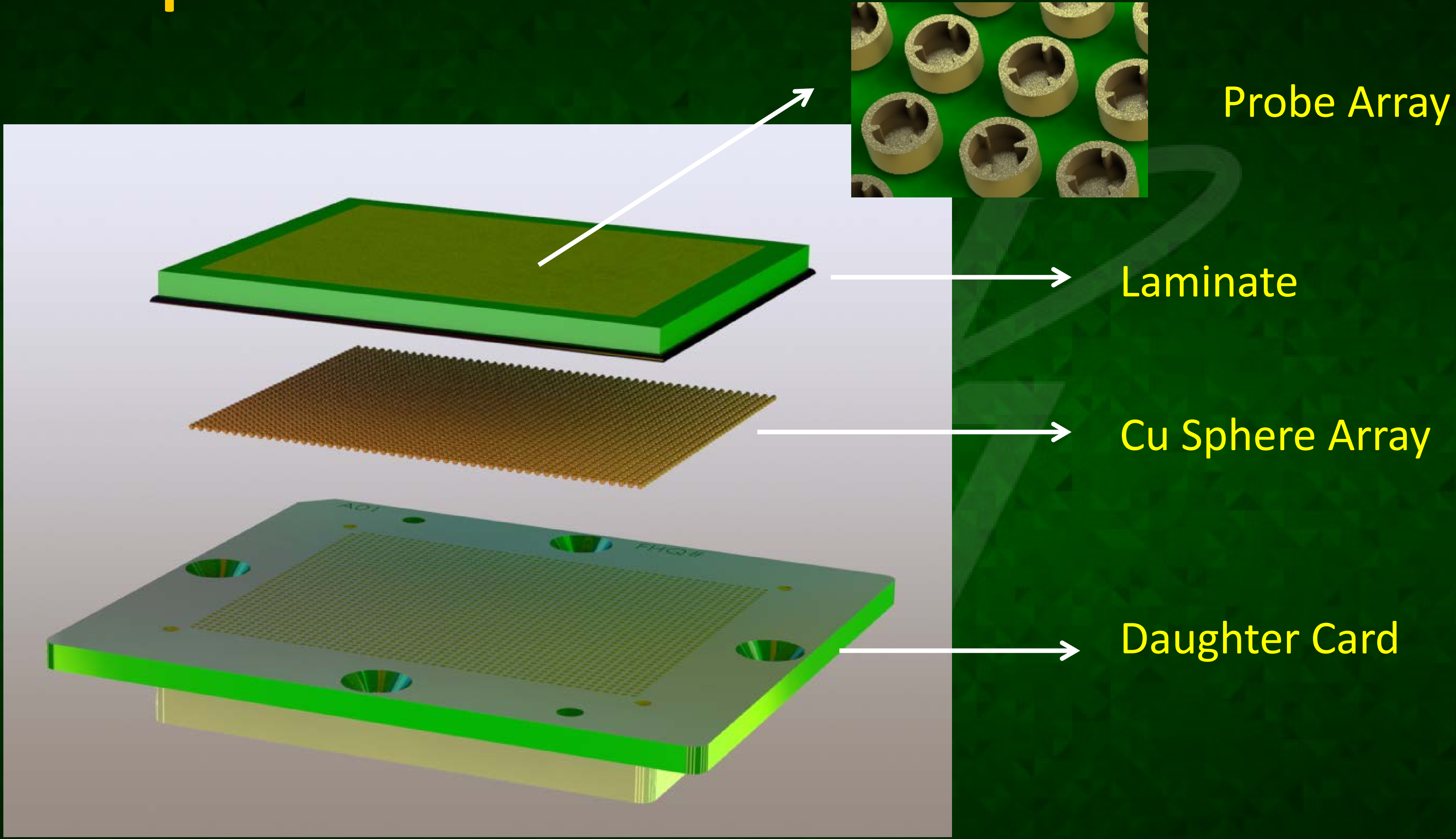
Stiffener

Gimbal Hardware Cross Section

Gimbal hardware dynamically planarizes probe array to DUT up to 100um

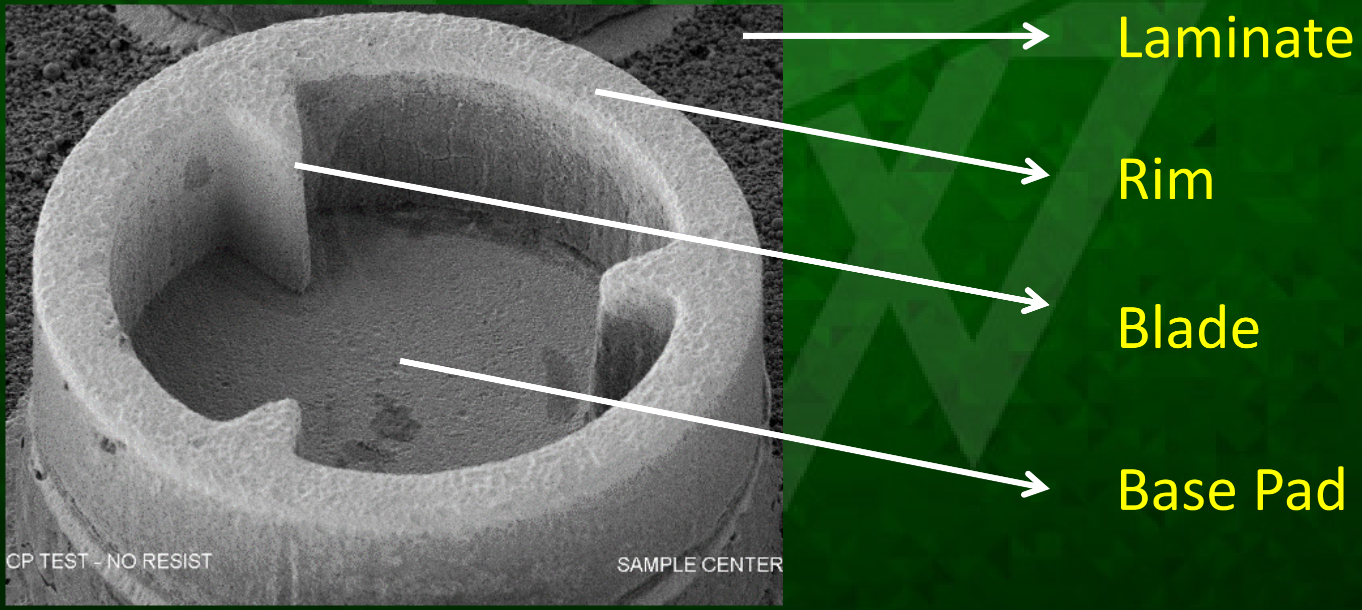


LFP Stack up



LFP Structure

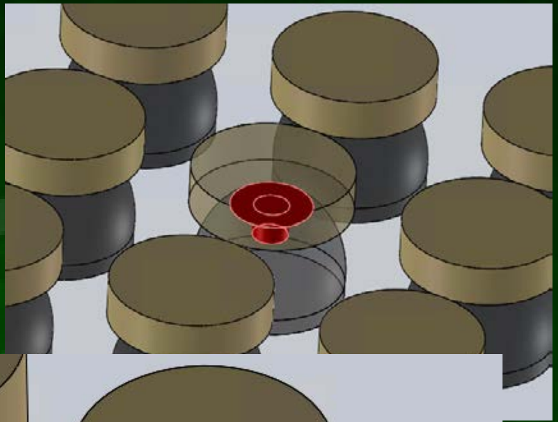
- Cu structure with Ni/Au plating
- Required load 7 g/pin
- Max pin count to date 30,000
- Current rating >1A per probe
- Lifetime >12K TD per probe (IBM high power application)
- Currently building on 150um pitch
- Fabricated at IBM



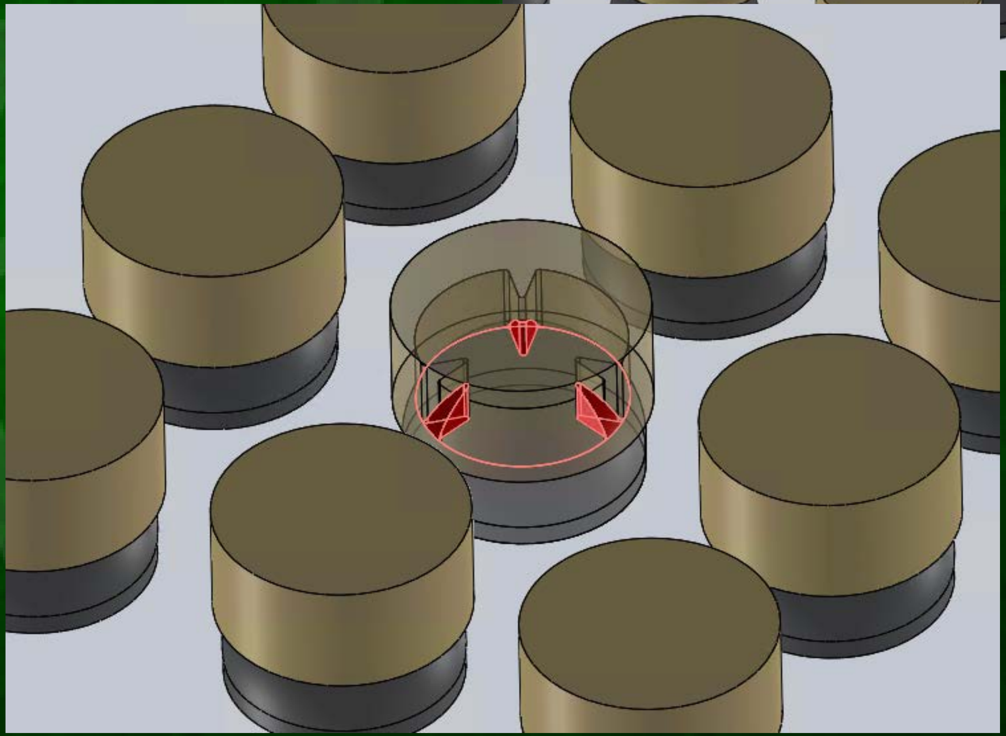
LFP Contact with C4

- Force required to deform the C4 is proportional to the displaced solder volume
- Blade features shear oxide layer, rather than compress
- Contact generates localized solder displacement below the blade, compared to global deformation of the C4

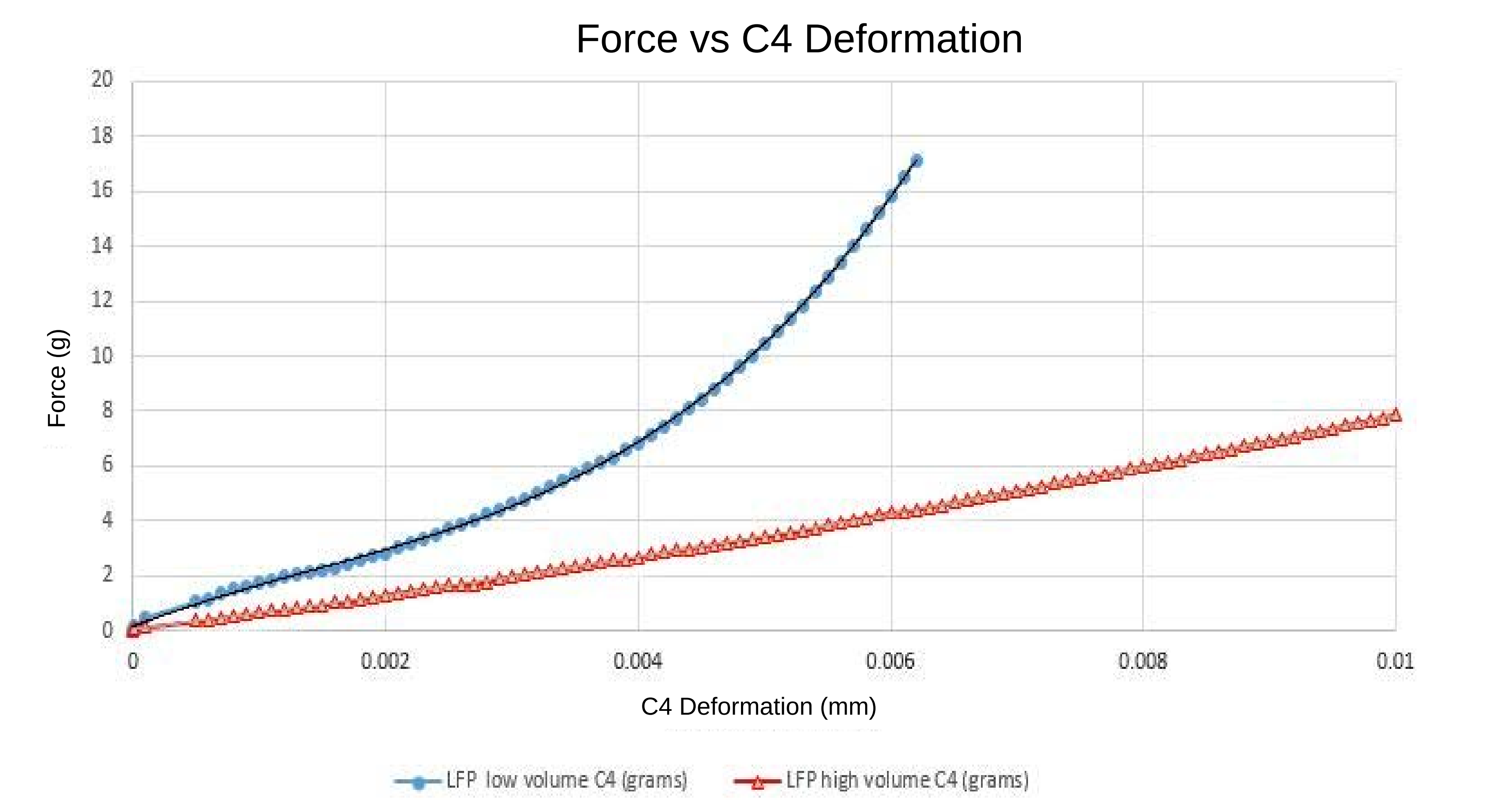
Probe-on-Organic



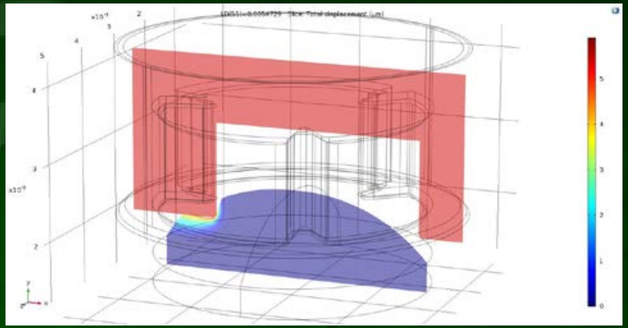
Low Force Probe



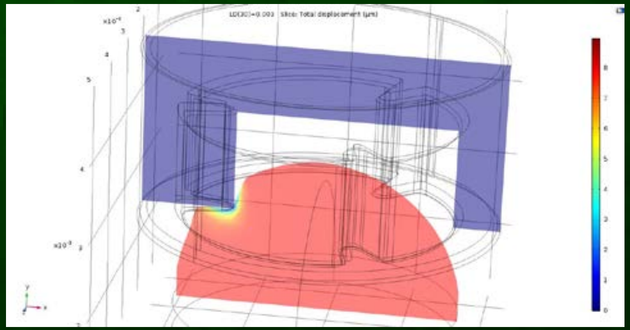
Force vs Deformation



Low Volume C4



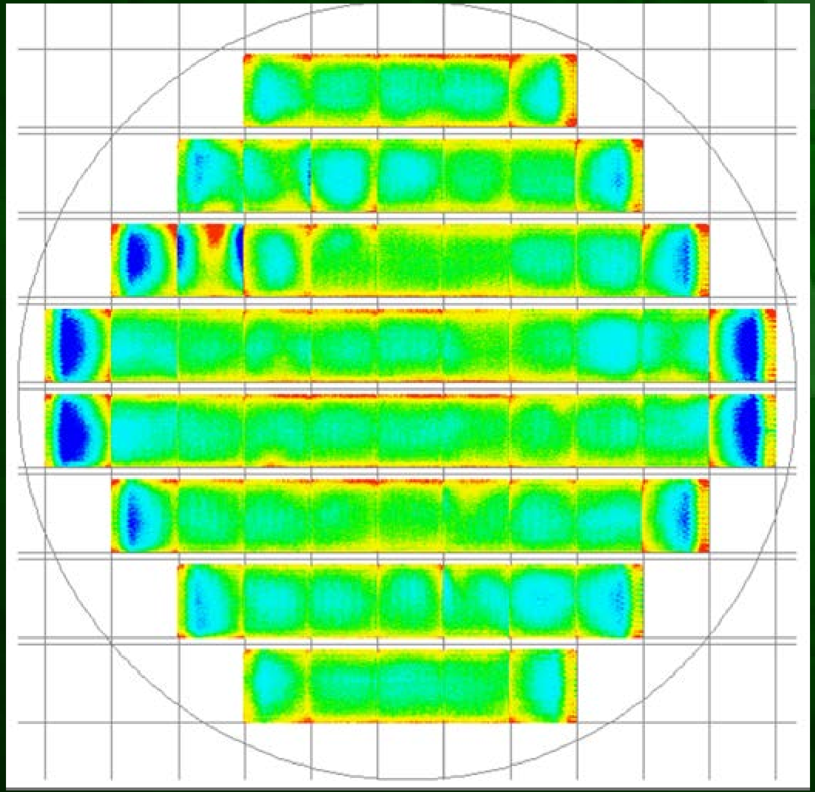
High Volume C4



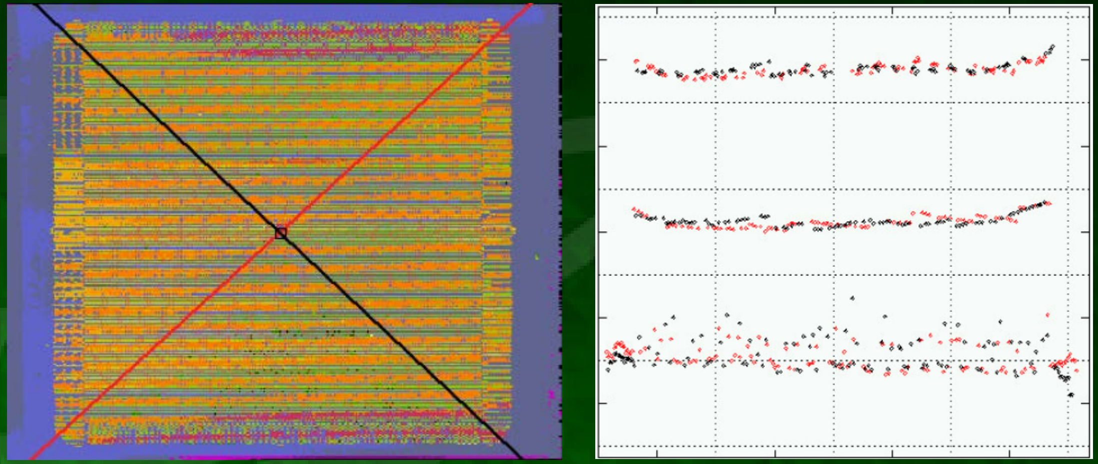
Contact Tolerance Stack Up

- Three primary factors

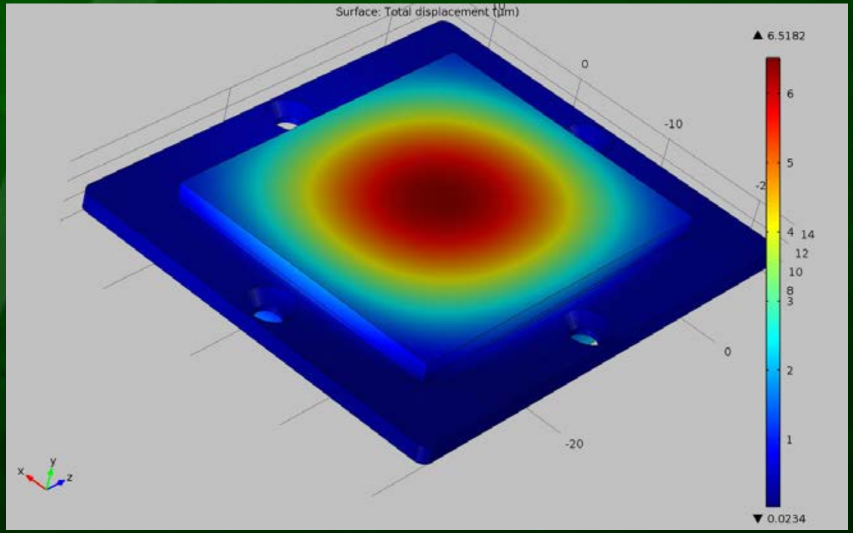
C4 Profile



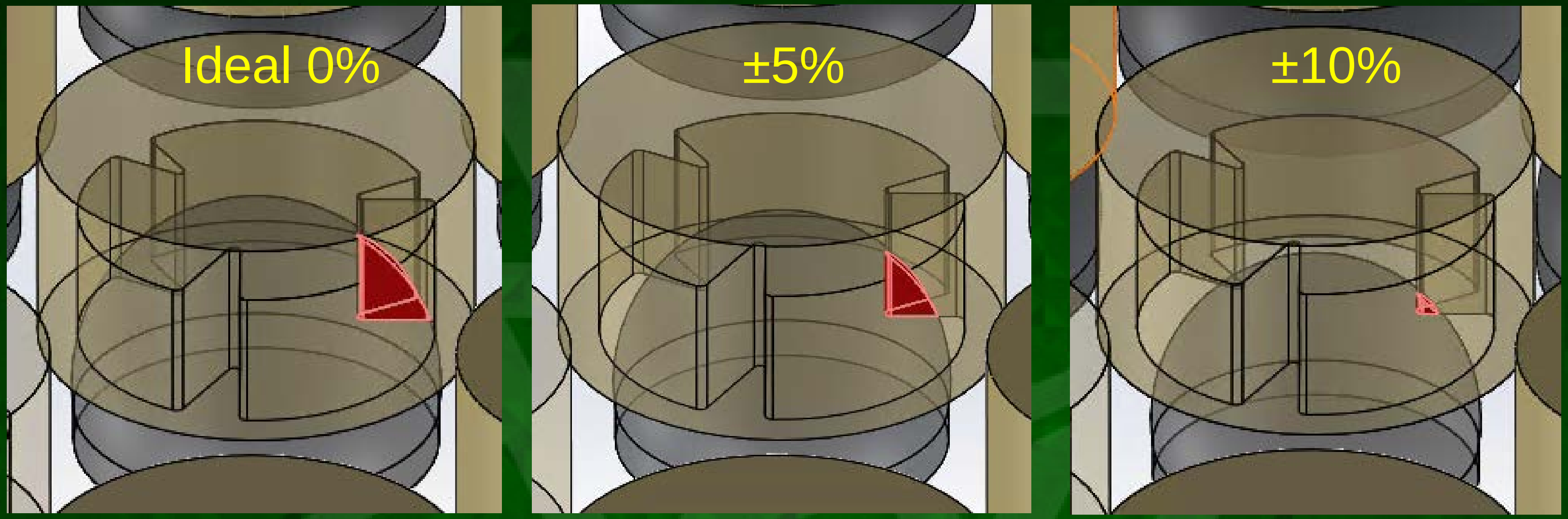
Probe Profile



Deflection Under Load



Contact Area by C4 Diameter Tolerance

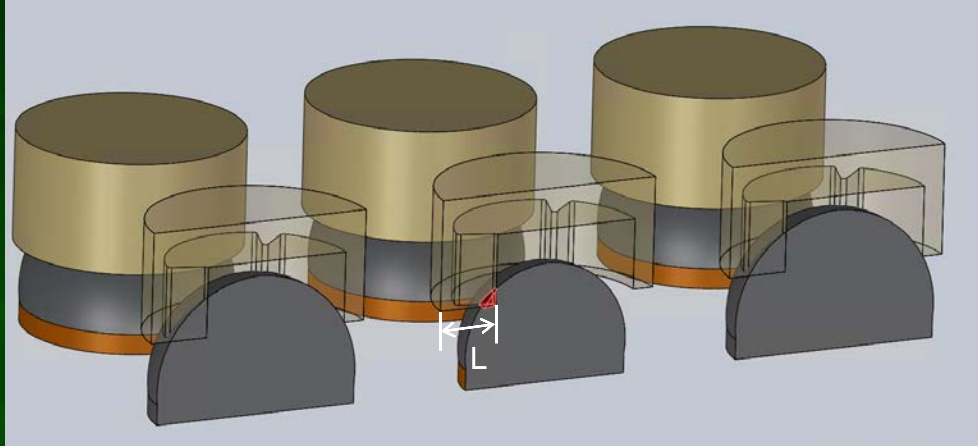


- Sufficient contact area is required for safe power delivery & robust contact
- Contact area is acceptable @ ±5% within die
- Contact area is poor @ ±10% within die

Variable Geometry

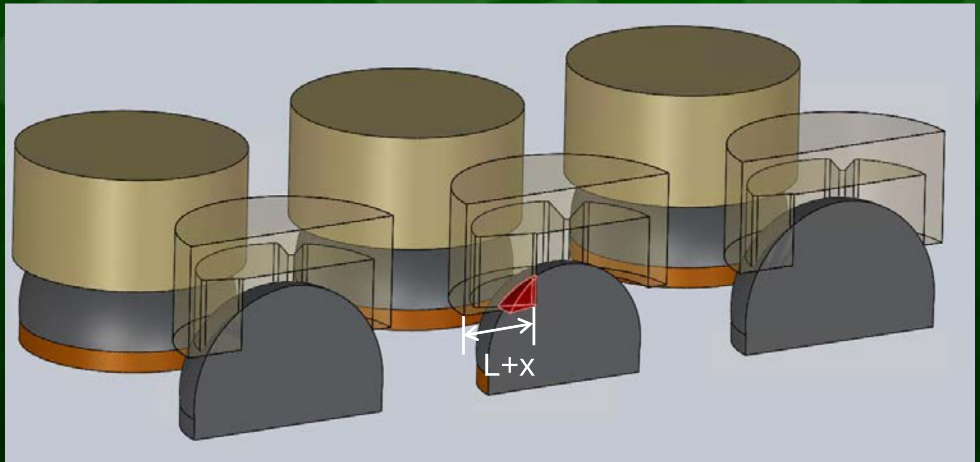
- Ability to vary geometry across the LFP array can compensate for substrate deflection or general flatness trends in the C4 and probe arrays

Without Variable Geometry



All blades are the same length with light contact on the smaller C4 in the center

With Variable Geometry



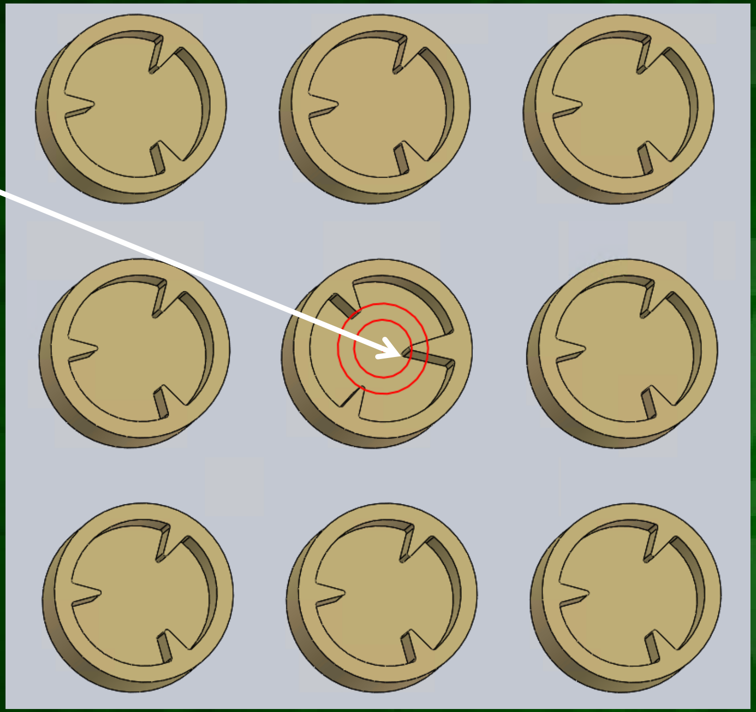
Center blades are longer for ideal contact throughout

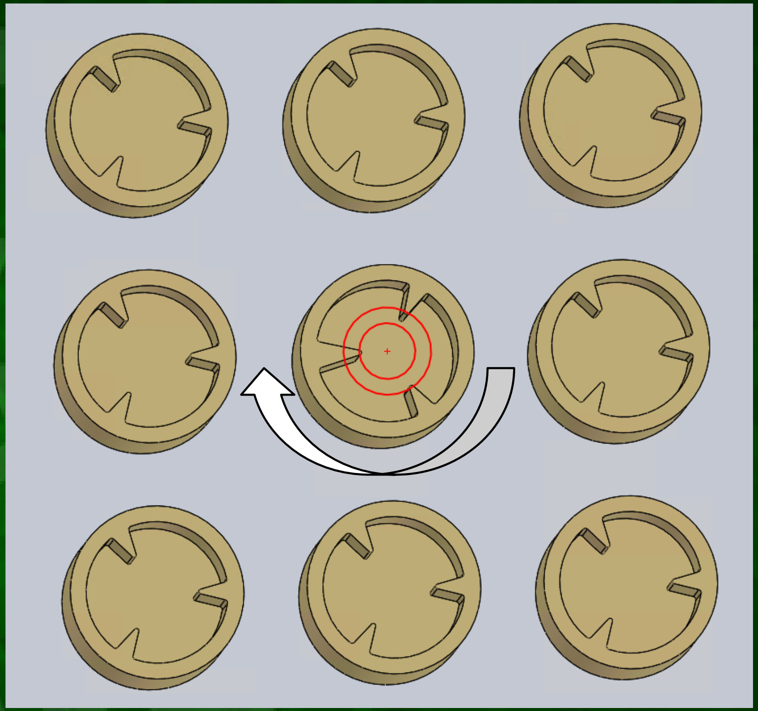
Additional Options with LFP

Pass 1 Probe Orientation

Pass 2 Probe Orientation

Critical pin rotated and with one longer blade



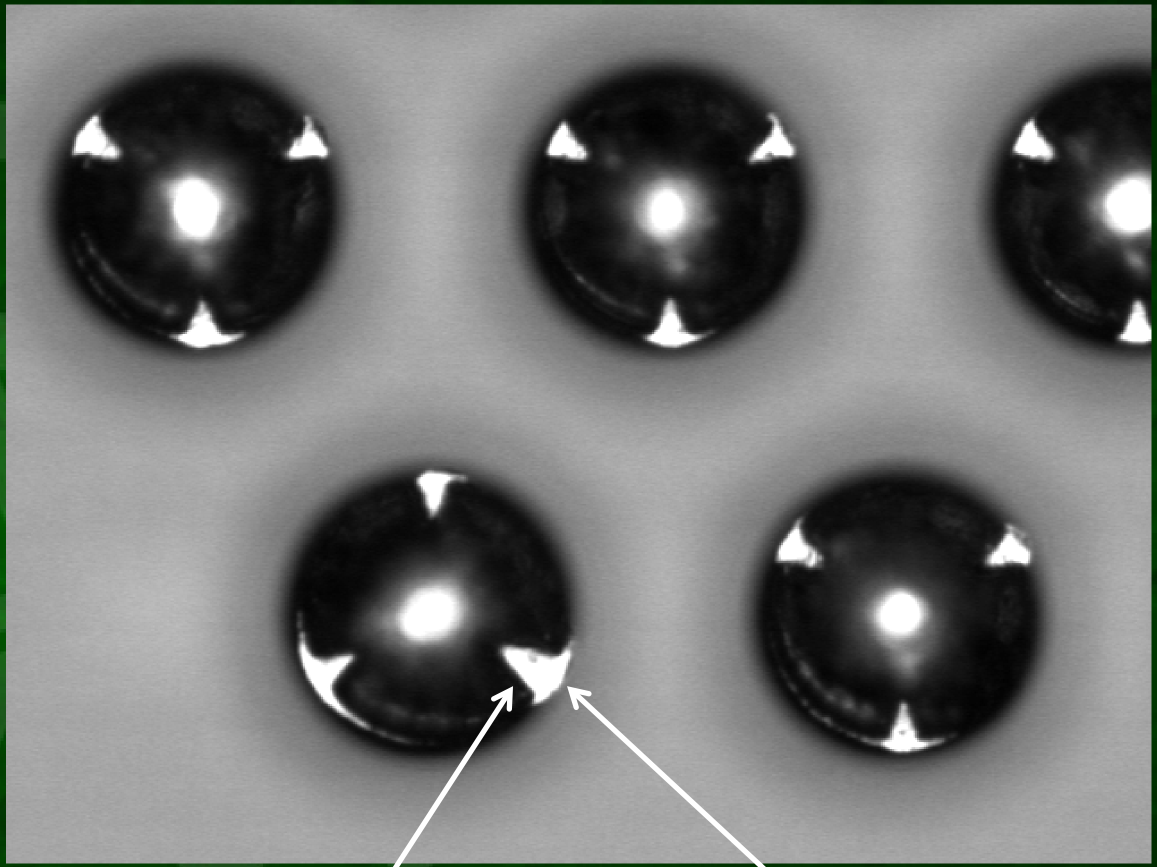


All probes rotated 180 degrees

- Critical pins are easily identified and ensured to make robust contact
- Rotation of probe geometry for pass 2 eliminates C4 reflow between passes

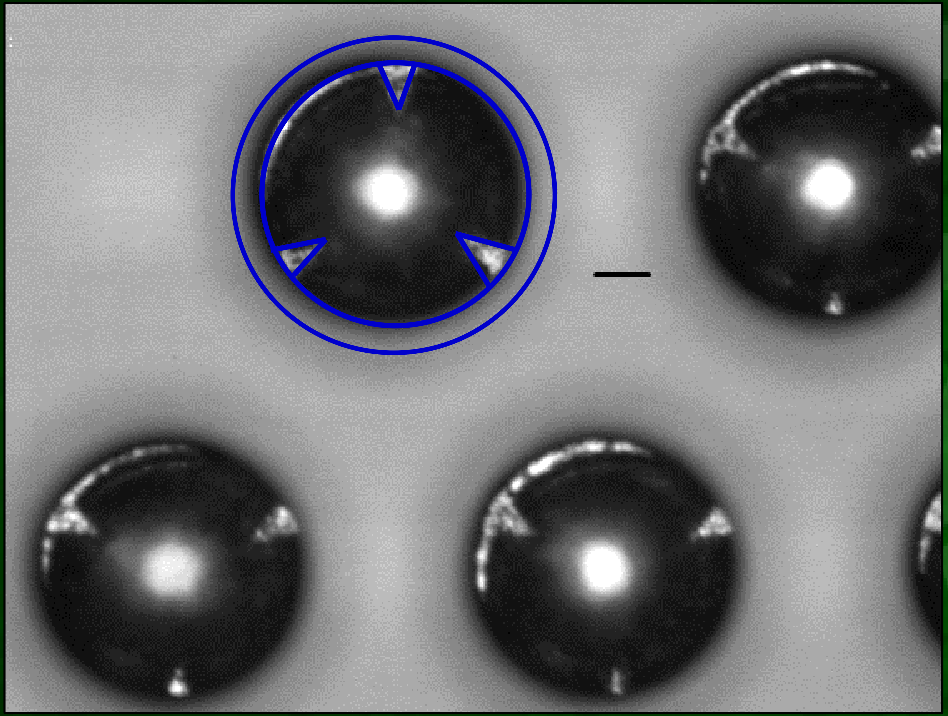
C4 Hit Marks

- Center of C4 remains undisturbed
- Local C4 deformation around probe mark only

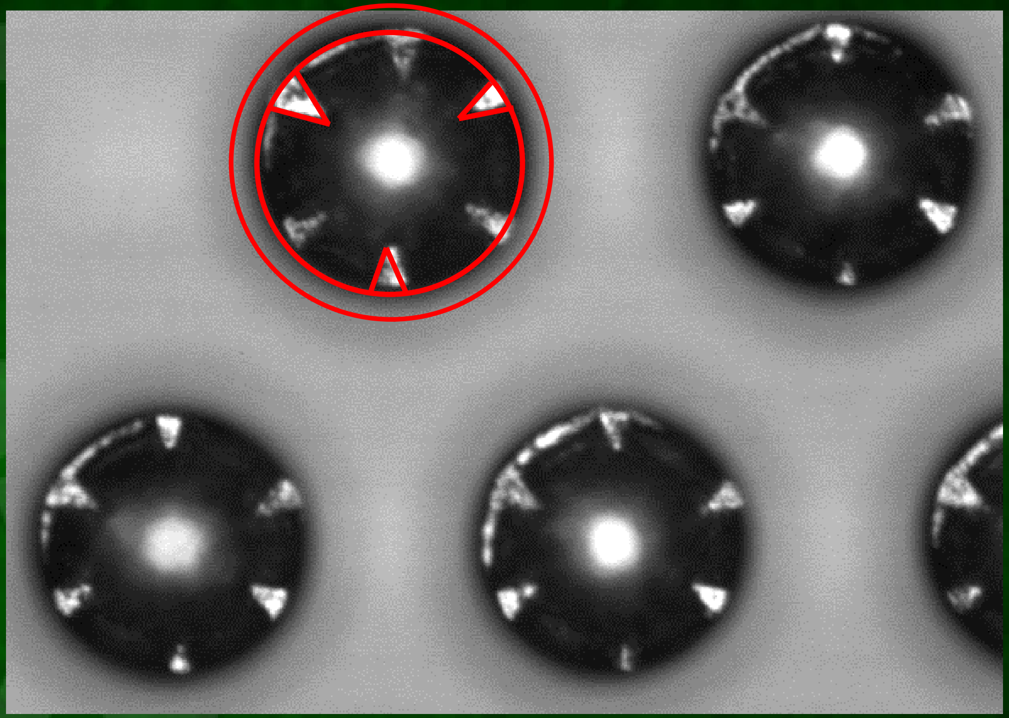


C4 Hit Marks

After Pass 1



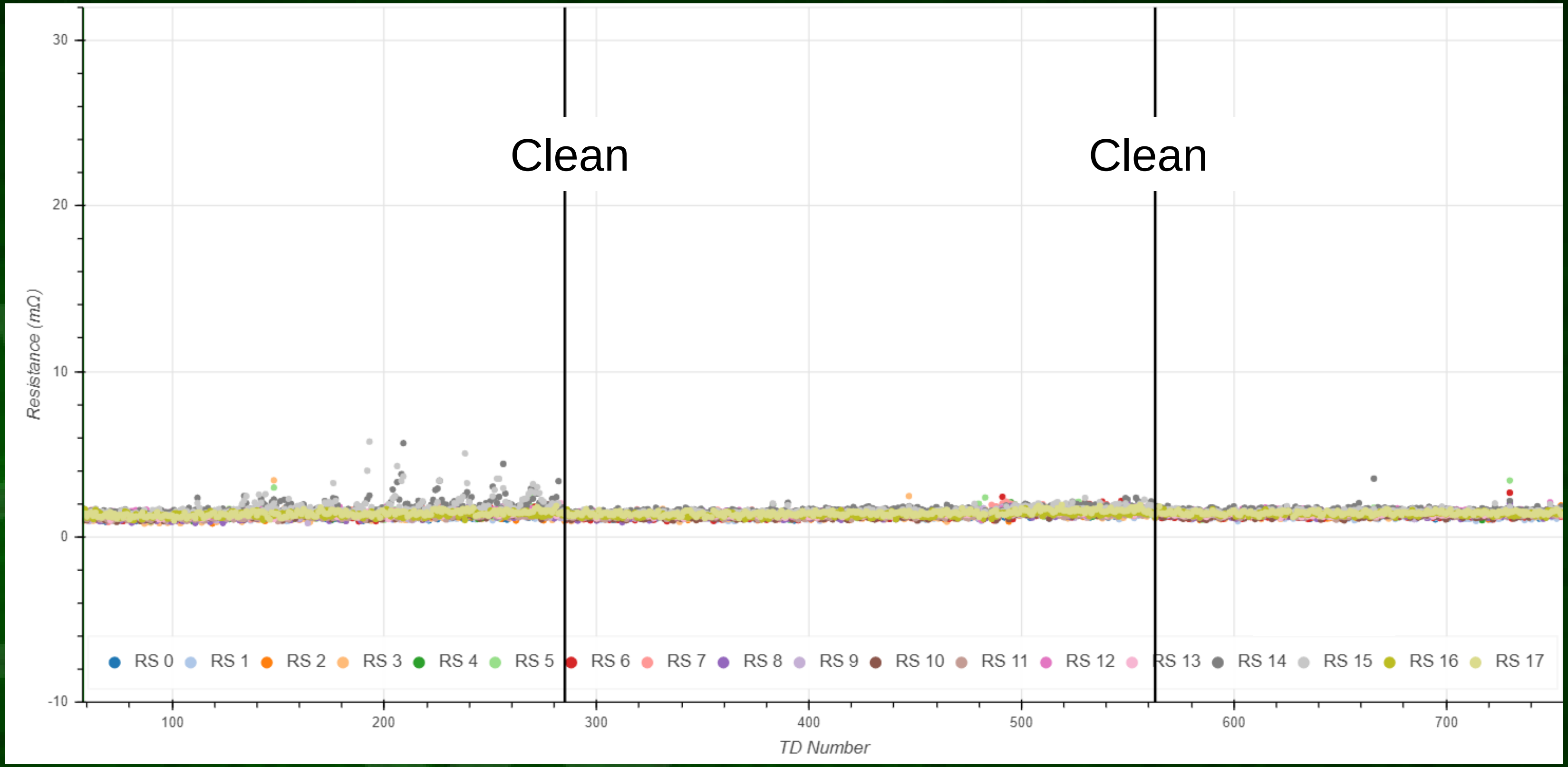
After Pass 2 (No C4 Reflow)



- Rotated pass 2 probe contacts fresh solder with no C4 reflow
- Undisturbed center may allow attach without C4 reflow

Contact Resistance

- Contact resistance is used as an indicator of electrical contact across the array and wafer
- This probe saw chips draw 450W at low temp
- At high temp, the probe can see as much as 750W



- Catastrophic melts do occur at these power levels (high power server application), further highlighting the need for a low cost, high power probe

Pros & Cons

Pros	Cons
Low Cost (and pin count independent)	Offline Clean
Low Force	No Repair (for catastrophic damage)
High Current	C4 Only
Variable Geometry	C4 Tolerance Sensitivity
No C4 Reflow	
Pin Identification	
Low Inductance	

Intellectual Property

- Gimbal Hardware
- Probe-on-Ceramic Structure
- Probe-on-Ceramic Fabrication
- Probe-on-Organic Structure
- Probe-on-Organic Fabrication
- Low Force Probe Structure
- Low Force Probe Fabrication

Future Development

- Probe plating metallurgy for reduced probe wear
- Probe compliance to widen allowable C4 tolerance window
- Pitch reduction for scalability

Summary

- The IBM server market utilizes large, high power, high pin count chips, driving the need for a high current, low force probing solution
- Probe force is a function of C4 diameter, height, & volume, all of which must be considered in the design of a low force rigid probe
- LFP improves on many aspects of previous rigid probing technologies, most notably a reduction of force, as well as the ability to vary geometry across the array to account for C4 profile trends
- LFP has demonstrated low contact resistance at high power levels for extended test times
- Rigid probes continue to offer IBM high performance at low cost

Acknowledgements

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Questions?