Presentation to
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Using MLOs to Build Vertical Technology Space Transformers

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Overview

1. Terminology
2. Benefits of MLOs vs MLCs
3. MLO Basics
4. MLO Variables
5. MLO Manufacturing Challenges
6. Processing MLO for Use as Space Transformer
7. Test Verification
8. Reliability
9. Performance Data
10. Conclusions

Terminology/Acronyms

1. ST – Space Transformer
2. MLO – Multi Layered Organic
3. MLC – Multi Layered Ceramic
4. BGA – Ball Grid Array
5. FR4 – Fiber Glass
6. ePTFE – Expanded Polyetraflouroethylene
7. C_{RES} – Contact Resistance
8. C4 – Controlled-Collapse Chip Connection
9. CTE – Coefficient of Thermal Expansion
10. OSP – Organic Solderability Perservative

Benefits of MLO vs MLC

1. Design/Manufacturing Time

    i. MLO – customer supplied at time of order
    ii. MLC – lead time of up to three months

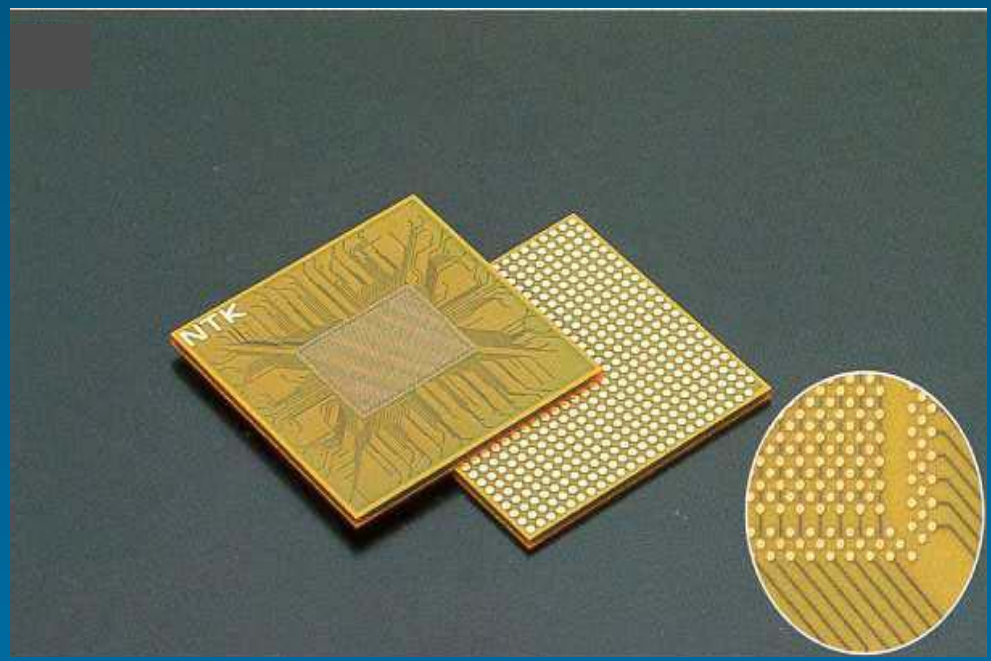
Benefits of MLO vs MLC

2. Cost
   i. Typical MLO package – $15 - $50
   ii. Custom designed MLC – NRE $10,000 - $15,000, $5,000 – $10,000 each (10 piece minimum)
3. Tighter Pitches (BGA side)
   i. Minimum pitch MLC 1.0 mm (typical)
   ii. Minimum pitch MLO 0.6 mm (typical)

MLO Basics

Application “Flip Chip” Packaging for

1. Microprocessors
2. ASICs
3. DSPs
4. Memory –
   Flash and DRAM



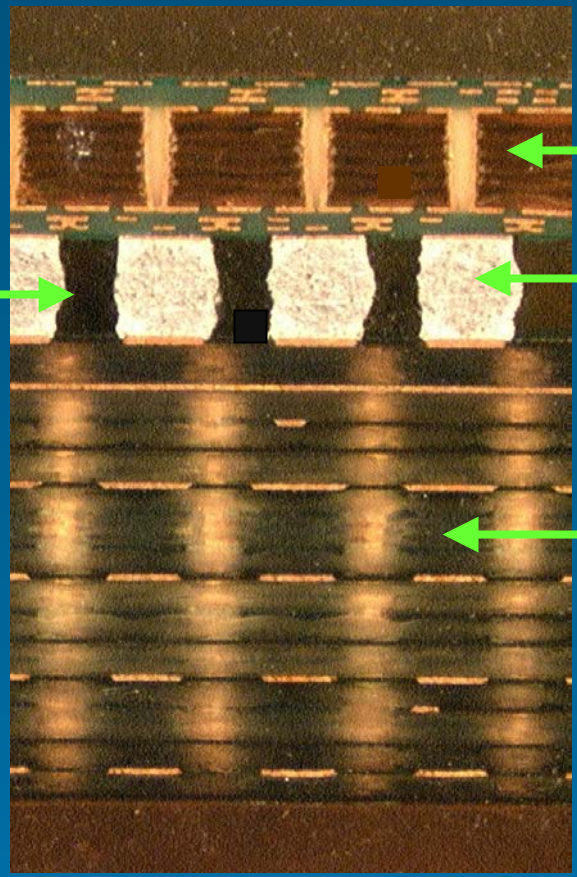
MLO Basics

1. Design: Determined by customer's packaging group
2. Vendors
   i. 3M (W.L. Gore)
   ii. IBM
   iii. Fujitsu
   iv. Ibiden
   v. Kyocera
   vi. NTK

MLO Basics

3. Composition
   i. FR4 – most commonly used fiberglass-type material
   ii. ePTFE – newer material
      1. resin composite – uniform structure throughout
      2. better machinability with laser
      3. better CTE matching
      4. ideal for dense arrays, tighter pitch size – device side

Typical MLO Assembly



MLO Variables

1. Thickness
2. BGA Pitch
3. Pad Composition
4. Solder Mask Opening
5. Metal Stiffener Rings
6. C4 Pitch
7. Flatness

MLO Manufacturing Challenges

Structural integrity

- Problem - BGA pattern voids under C4 area
- Solution - Underfill on BGA side

BGA Pitch

- Problem - Accommodate smaller pitch requirements
  - 1.27 mm – past
  - 1.00 mm – today
  - 0.80 mm – soon
  - 0.60 mm – future
- Solution - Create custom fine pitch solder stencils

MLO Manufacturing Challenges

Pad Composition

- Problem – OSP and solder on pads
- Solution – Remove and plate with nickel and gold

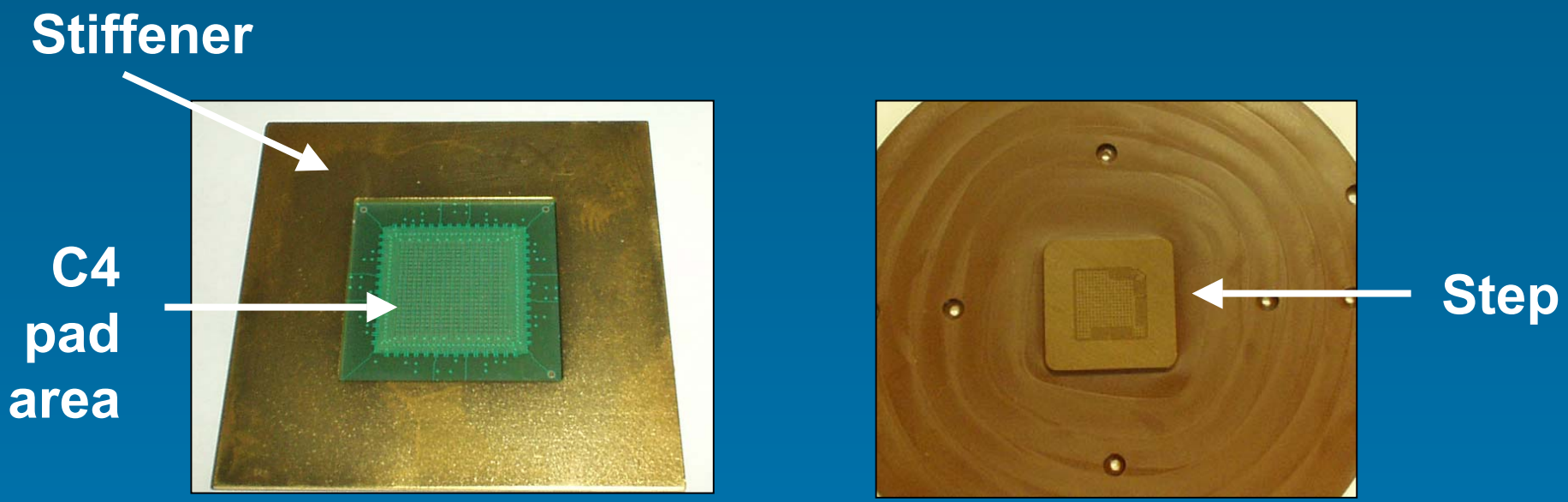
Solder Mask Opening

- Problem – Solder mask opening too small
- Solution – Remove solder mask (proprietary process)

MLO Manufacturing Challenges

Metal Stiffener Ring

- Problem – C4 pads recessed below stiffener
- Solution – Stepped Cobra® head



MLO Manufacturing Challenges

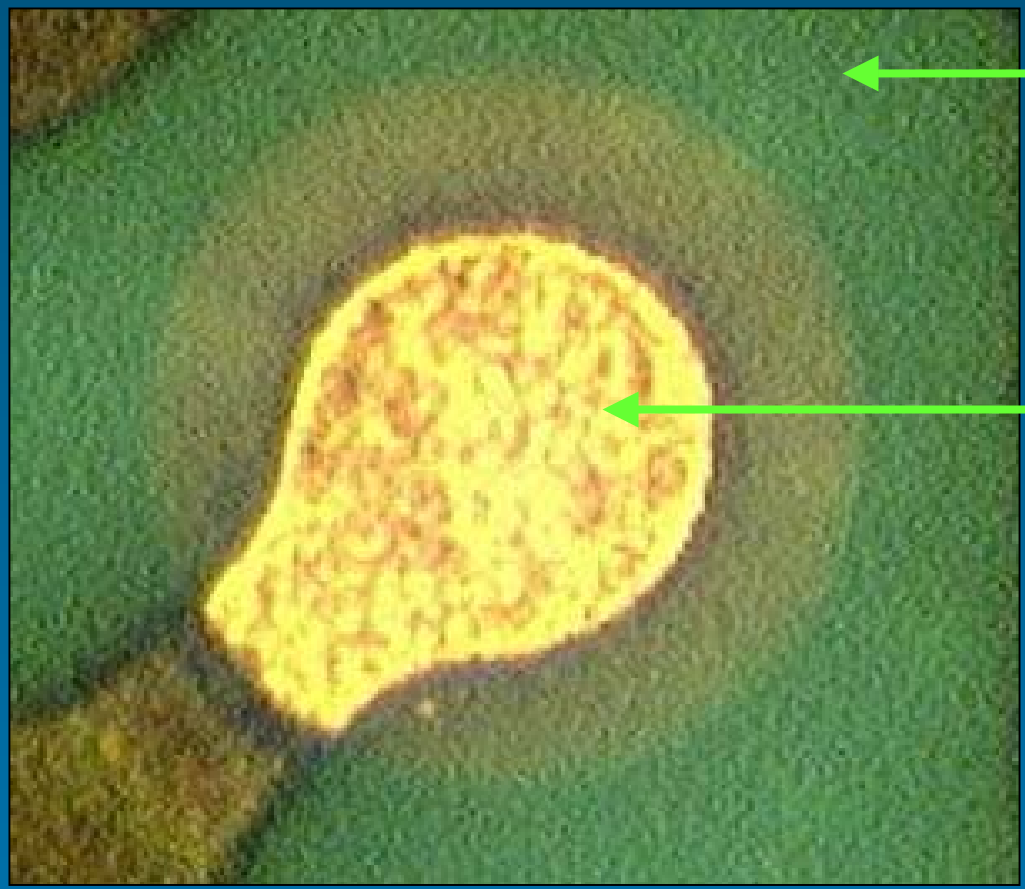
C4 Pitch

- No issue with current fine pitch contact technology

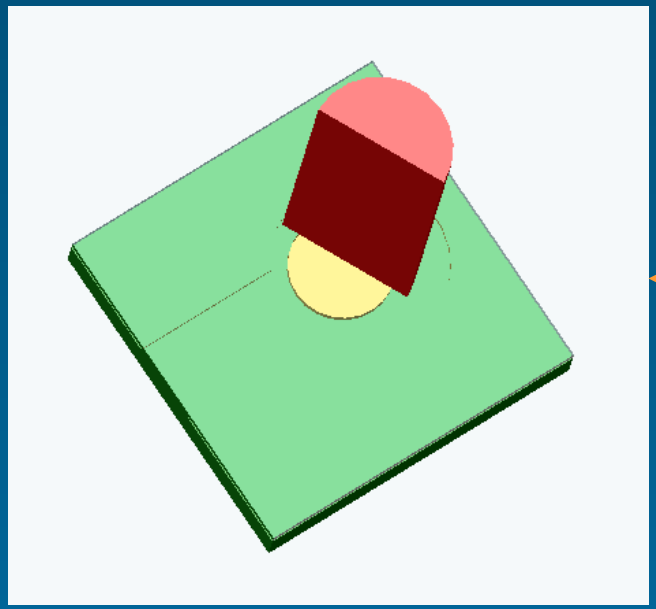
Flatness

- Problem – Warping of extra-thin MLOs
- Solution – Custom lap at assembly

Processed C4 Pad

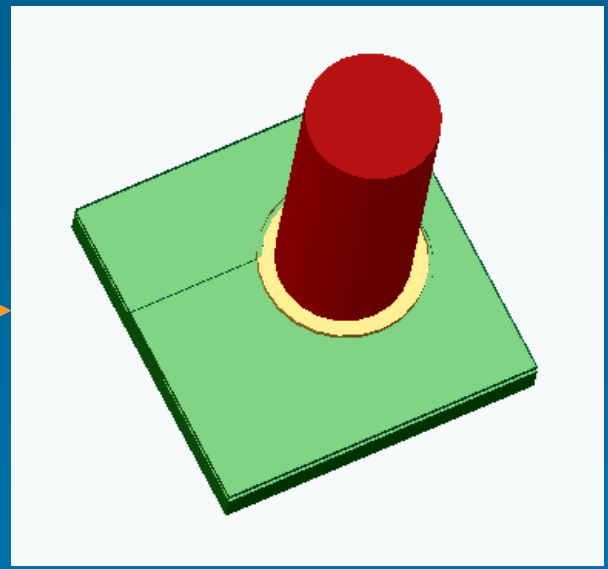


MLO Processing



Unprocessed MLO – soldermask still on pad area

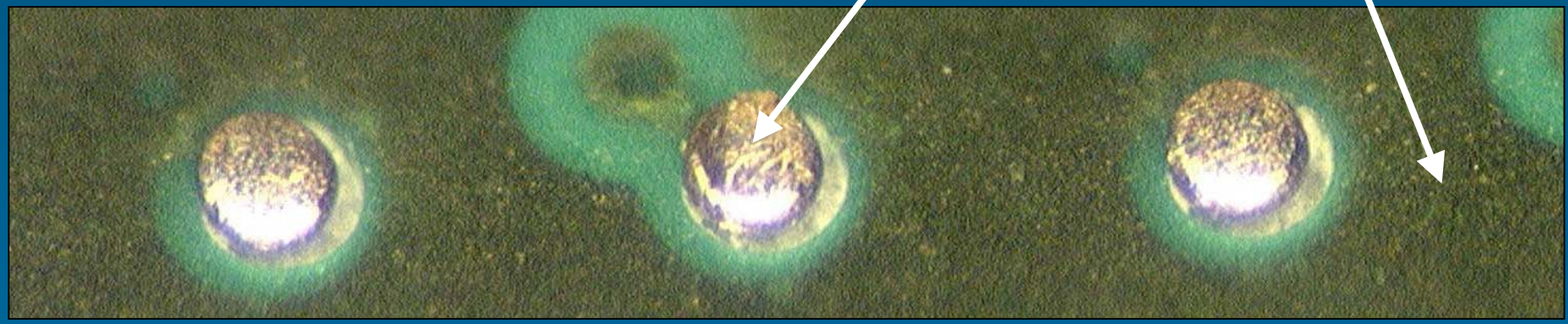
Processed MLO – solder mask cleared from PAD area



MLO Processing

Preparation

1. Remove solder



2. Remove solder mask exposing pad
3. Nickel and gold plate

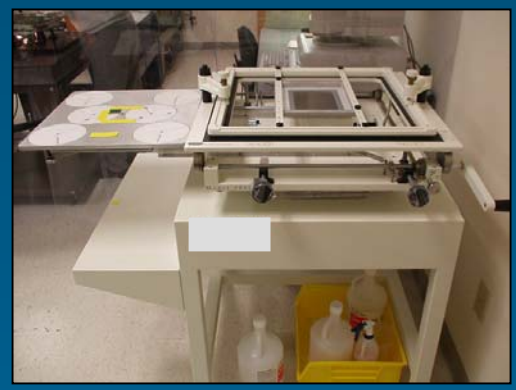
Post-Processing Inspection

1. Visually inspect C4 pads for damage
2. Verify alignment of C4 pads within .0003” in true position
3. Measure flatness of C4 area – .0005”or less
4. Measure flatness on entire MLO – .0015” or less
5. Test for allowable leakage <5 nA @5VDC

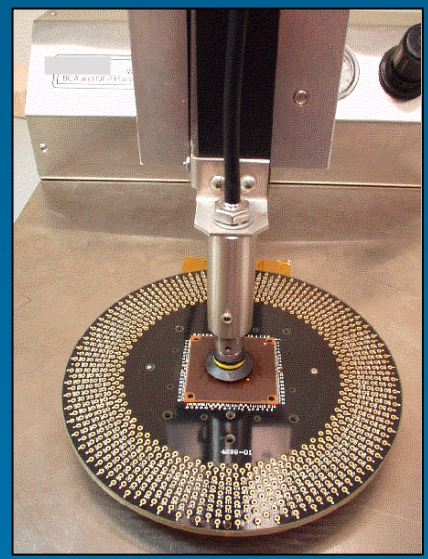
Bonding MLO on Probe Card

BGA Attach

1. Equipment:
   - i. Solder Stencil Printer – apply solder to BGA pads
   - ii. Programmable Reflow Oven



2. Fixturing:
   - i. BGA Alignment Placement Tool – align and place MLO to PCB

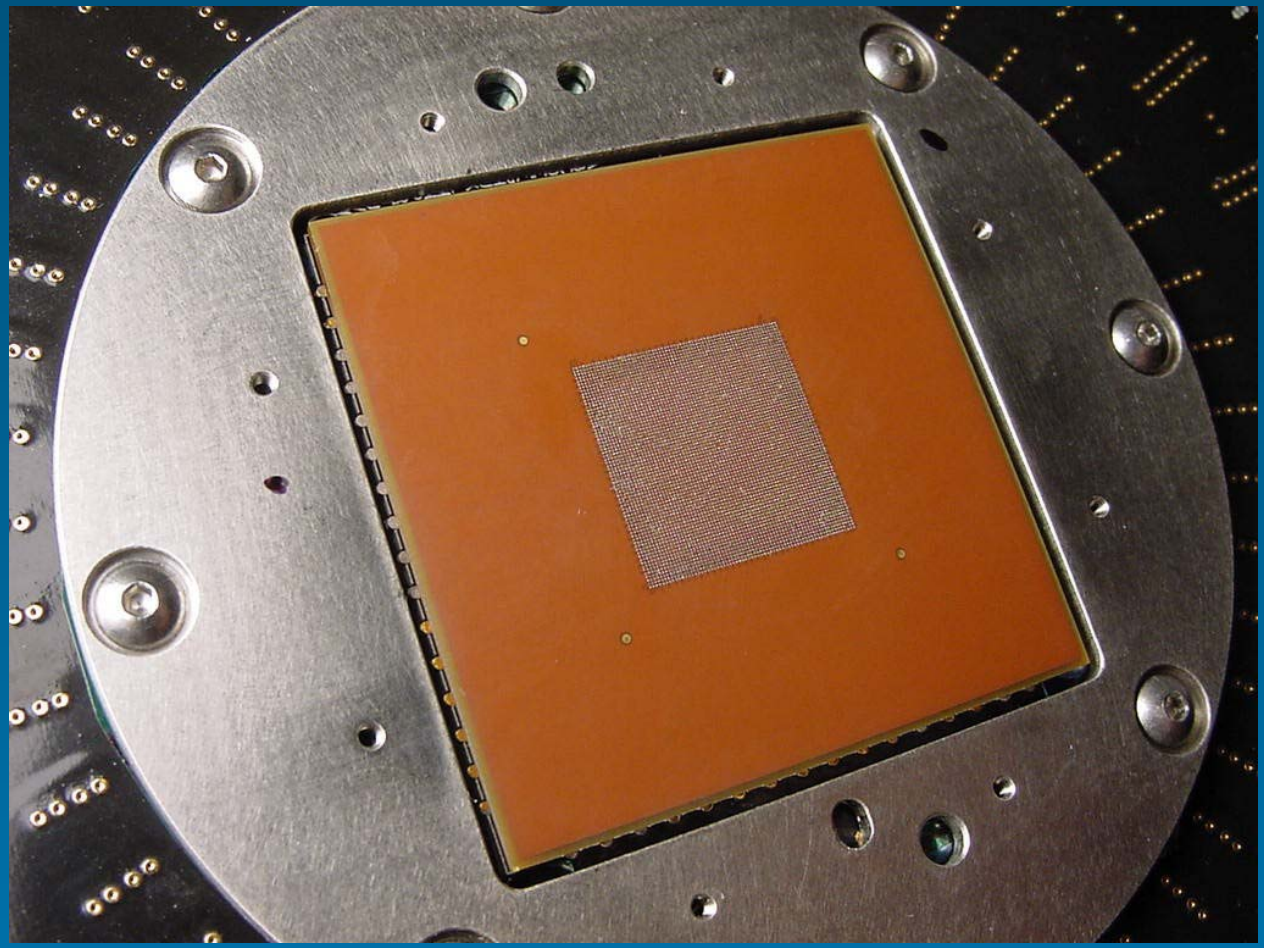


Bonding MLO on Probe Card

BGA Attach Techniques

1. Apply solder paste and solder spheres to BGA pads
2. Reflow solder
3. Apply solder paste to PCB
4. MLO aligned and placed on PCB
5. Reflow the assembly in programmable oven
6. Apply underfill to MLO
7. Inspect

Completed Space Transformer



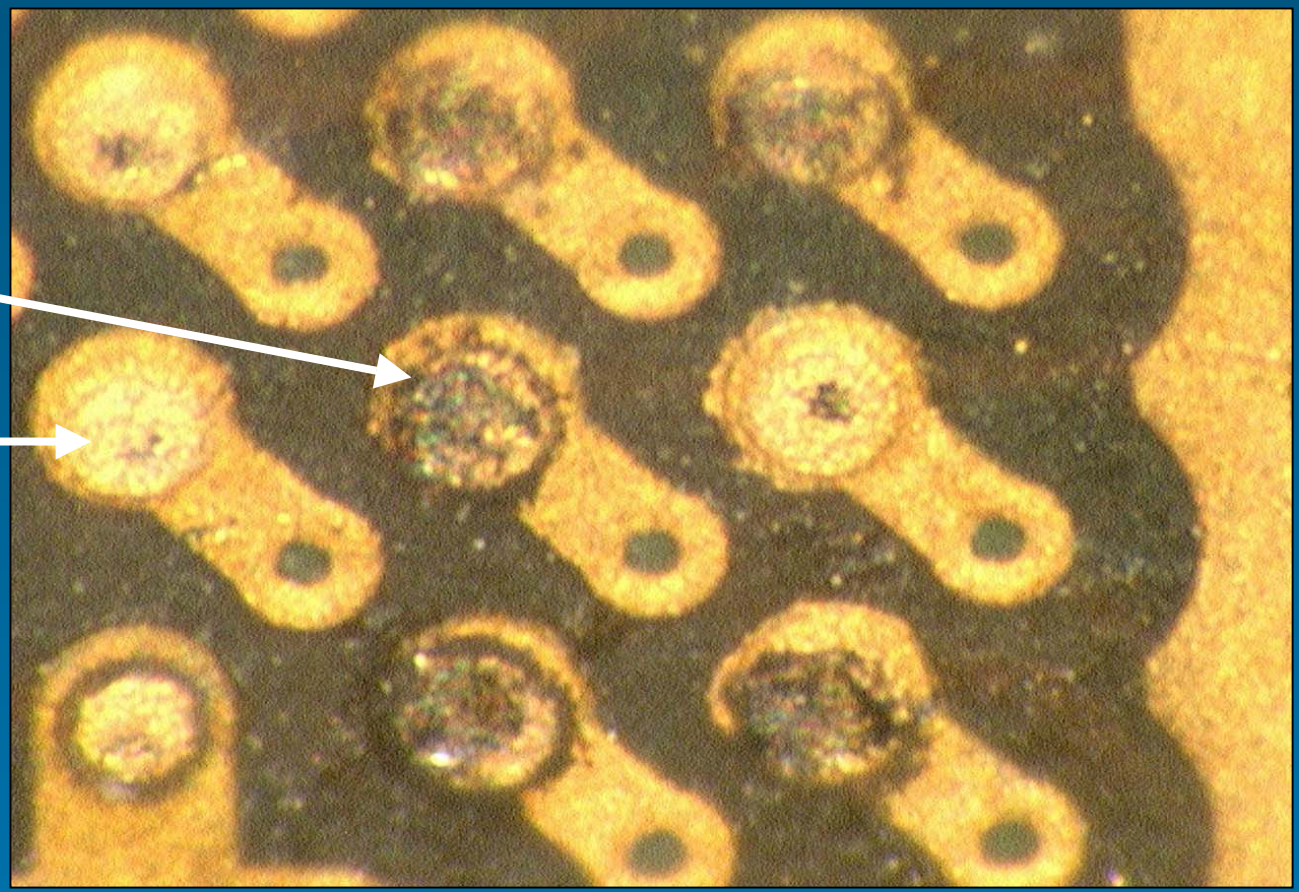
Verification of Probe Card

Final Assembly Test

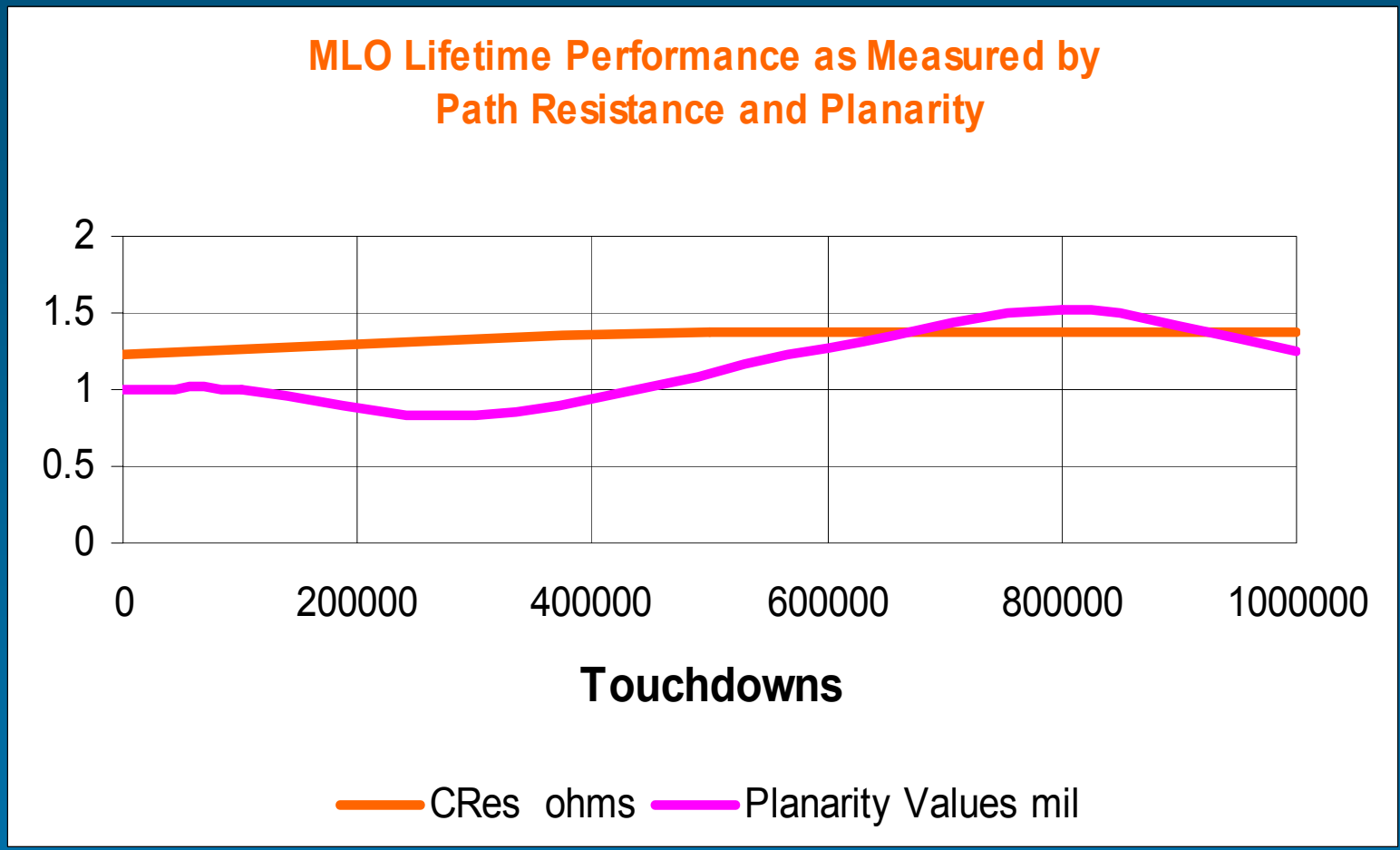
1. Leakage
2. Bulk Planarity
3. Overdrive leakage
4. Alignment
5. Full planarity & C_{RES}
6. Wire Check
7. Components

Performance Data

Typical Pad Wear



Performance Data



Conclusion

MLO/ST technology benefits:

1. Fast turnaround as compared to custom-designed MLC
2. Lower cost probe card cost due to lower ST costs
3. Closer match to actual “real world” application due to similarity of materials
4. Performance equal to more expensive MLCs
5. Ideal, cost-effective solution for short-runs of ASICs and other specialty devices