IEEE SW Test Workshop

Semiconductor Wafer Test Workshop

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Touch count improvement for Cantilever Probe cads

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Introduction

- ON Semiconductor Philippines Inc. has its own Probeshop capable of building blade and epoxy cards. The shop is building single site to 64 sites probe cards with a maximum of 4 layers. The cantilever cards can support high temperatures, up to 175C.
- The shop designs and continuously develops cantilever probe card technology.
- Automotive requirements and specifications are supported.
- Touch count limit is a key metric for probe cards, with higher limit desired without adverse affects to Test.

Objectives

- Solve problems to increase touch count limits of cantilever probe cards in manufacturing
  - Special focus on high temperature epoxy cards
- Demonstrate how the touch count improvement has direct impact on QUALITY and Cycle time

Top Causes of Early Rebuild of Cards

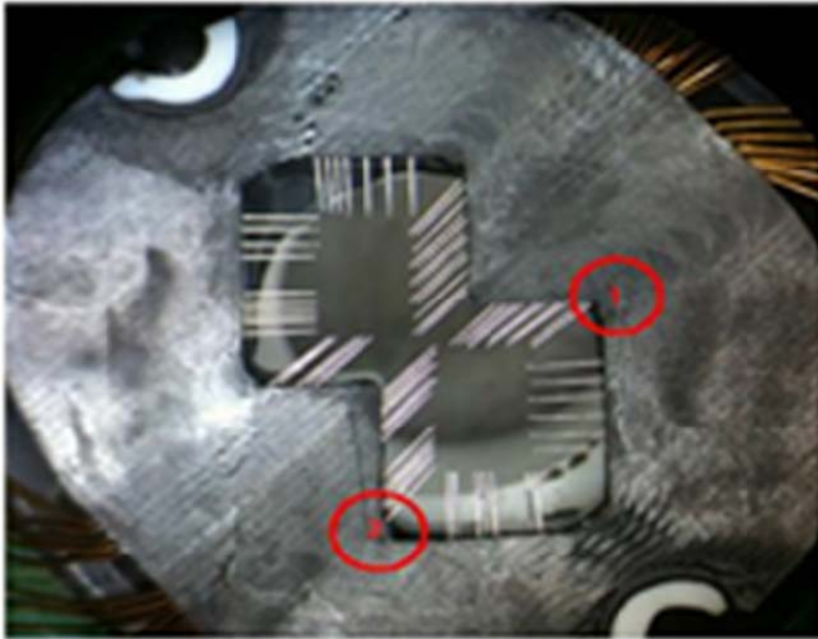
Averaging <75K touch counts per probe card before rebuild

- Needles sway or move; especially in high temperature testing
- Split needle marks
- Setup handling (overdrive setting)
- Short probemarks
- Bent probe needles, “kneeling needles”
- Premature disposition to rebuild the card.
- Probemark >25% allowable area (automotive rejectable)

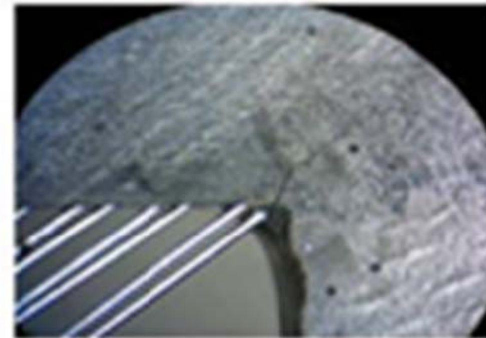
The Continuous Improvement Journey Begins…

Key Item #1: Epoxy change

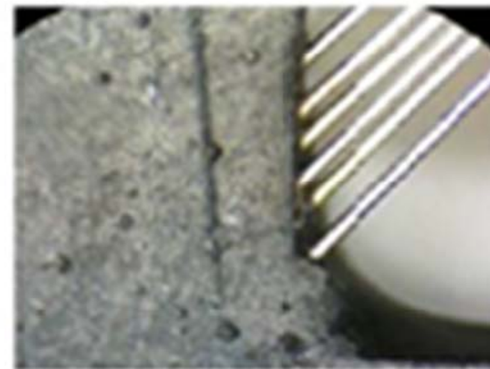
- **Issue: Manual mixing of two-part epoxy (resin + hardener)**
  - Can produce imbalanced mixture
  - Needle movement due to cracked epoxy, lift off, void (porous)
- **Solution: change from two-part to *one-part epoxy***



Cracked epoxy locations 1 and 2



Location 1

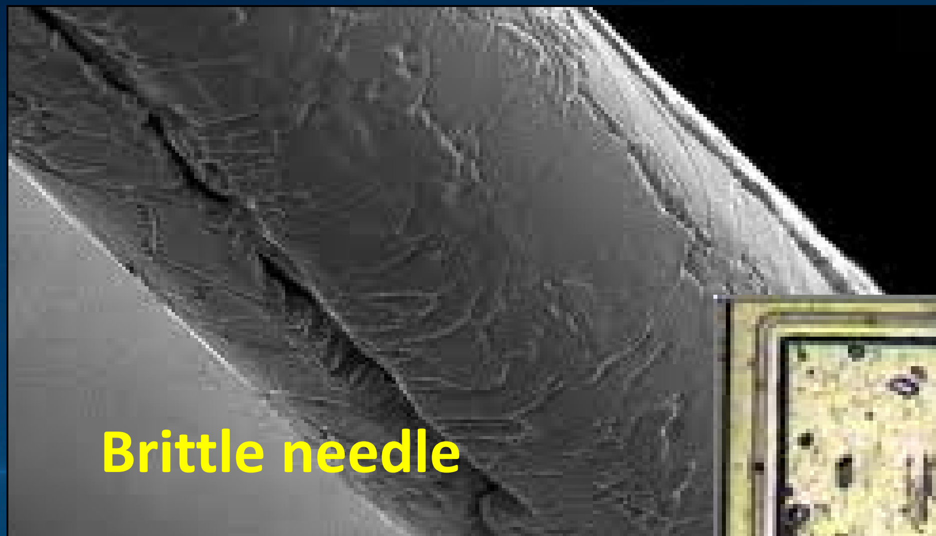


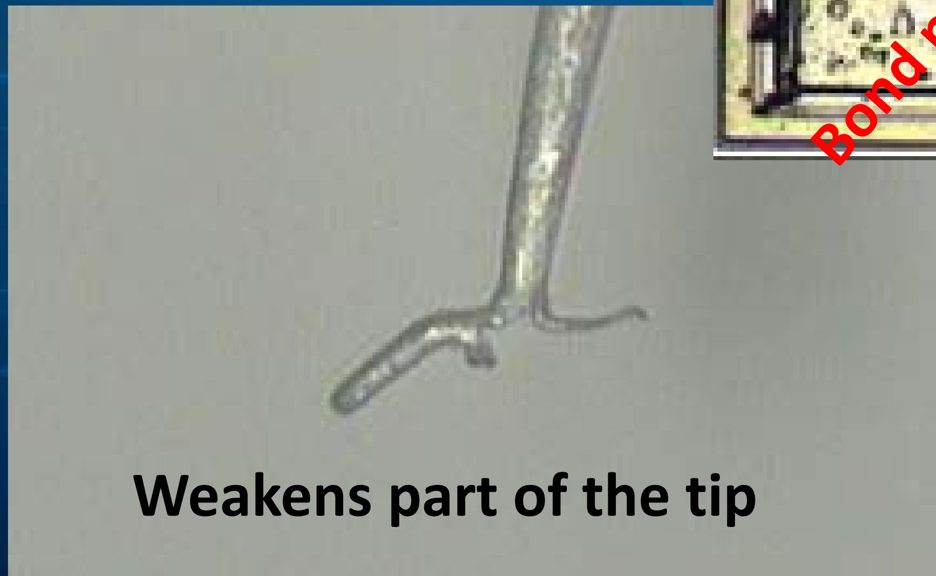
Location 2

Key Item #2: Removing Electrochemical Etching

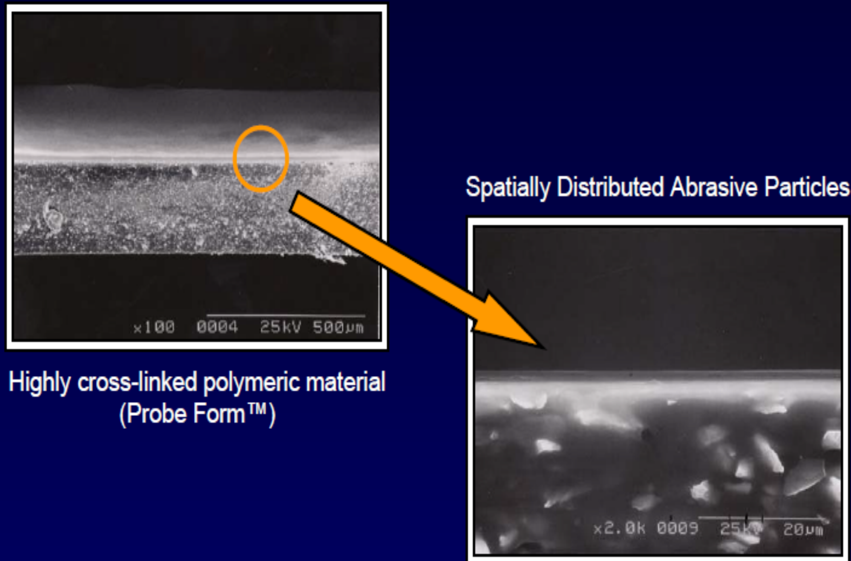
- **Issue: Electrochemical etching process for probe tips**
  - Manually done per probe. Uncontrollable process. Some tips etch more, some less.
  - Gang needles (connected to each other) etch faster
  - CRES issue from formation of oxide at the tip
  - Various amounts of tip deformation
  - Cleaning requires DI water + alcohol; doesn't guarantee 100% removal of oxide
  - Must follow with planarity and alignment adjustments
- **Solution: Needle reshaping process change from electrochemical etching to Gel pad**

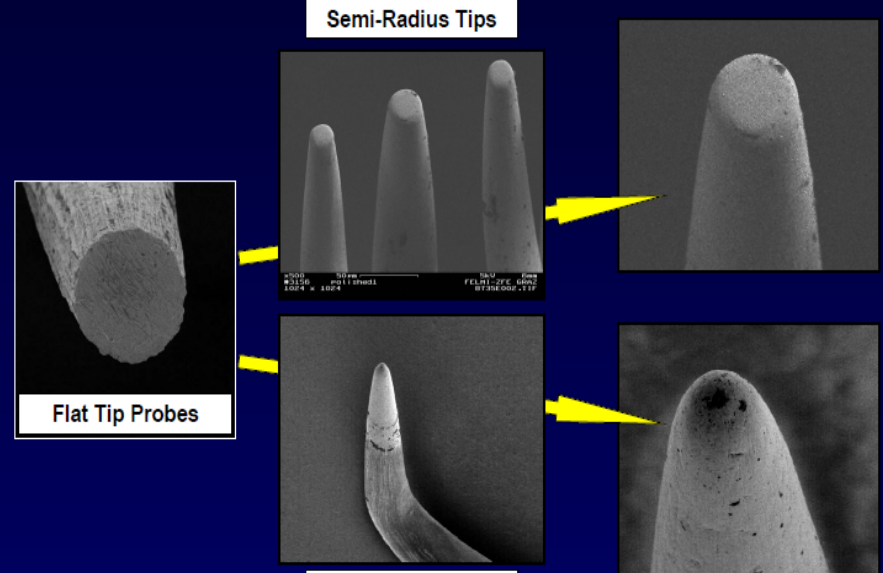
Electrochemical Etching Issues





Key Item #3: Retention of Tip Shape in Test

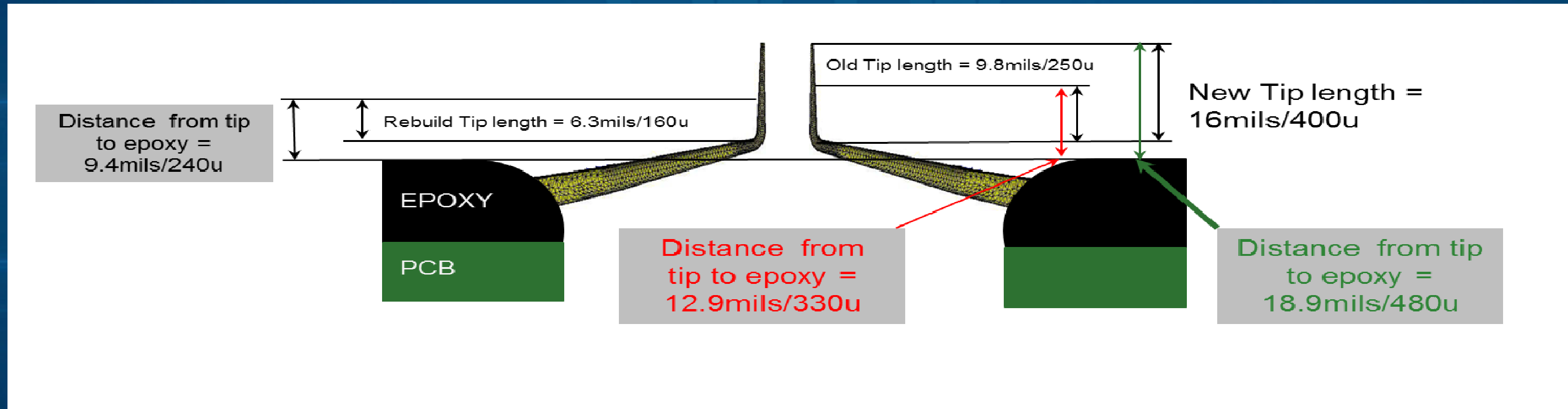




- **Issue: Tips loose their shape quickly in test**
  - Probecards are subject to multiple Z-up movement on an auto sanding machine. This can occur on a prober or probecard analyzer
- **Solution: use Gel pad for probe tip reshape**
  - No probe realignment needed
  - No chemical hazard
  - Re-shape is evenly distributed

Key Item #4: Needle Tip Length Optimization

- Issue: One tip length does not fit all probes
- Solution: Experiment for optimal shaft and tip lengths
  - Consider shaft diameter, tip force, and scrub mark area / length



Needle Shaft diameter	From	To	Comment
7 mils	355 mils	525 mils	For the first layer with 170 mils increment on succeeding layer
8 mils	250 mils	400 mils	For the first layer with 170 mils increment on succeeding layer

Key Item #5: Build Fixture Enhancement

- **Issue:**

Conical Fixture Problems

  - Tendency to have thick epoxy (effective shaft length more variable)
  - Additional layers result during build

- **Solution:**

Pyramid Fixture

  - Even epoxy application, gives shaft length control, prevents scratches
  - Needle fan out is controllable.
  - Fewer layers, simpler needle stack-out

Build fixture Enhancement

Same probecard build on two different Build fixture.

Conical Spider

4 Layers

Epoxy clearance

Pyramid Spider

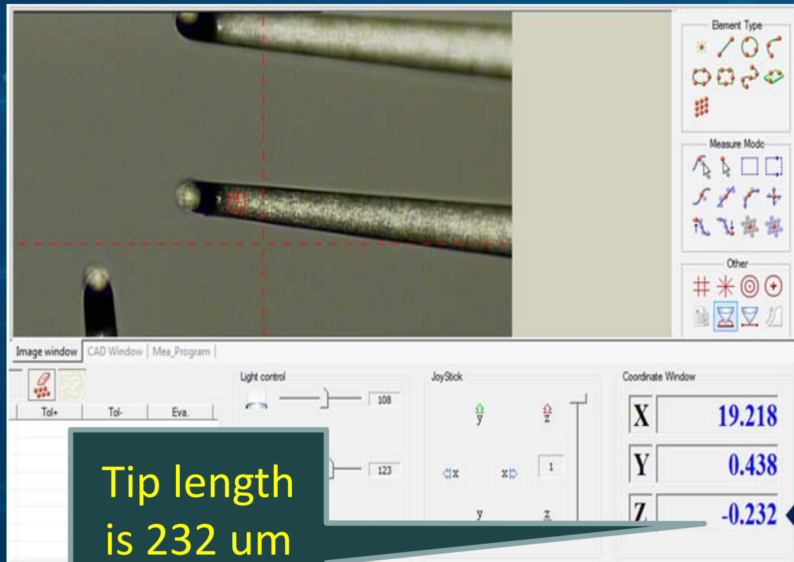
3 Layers

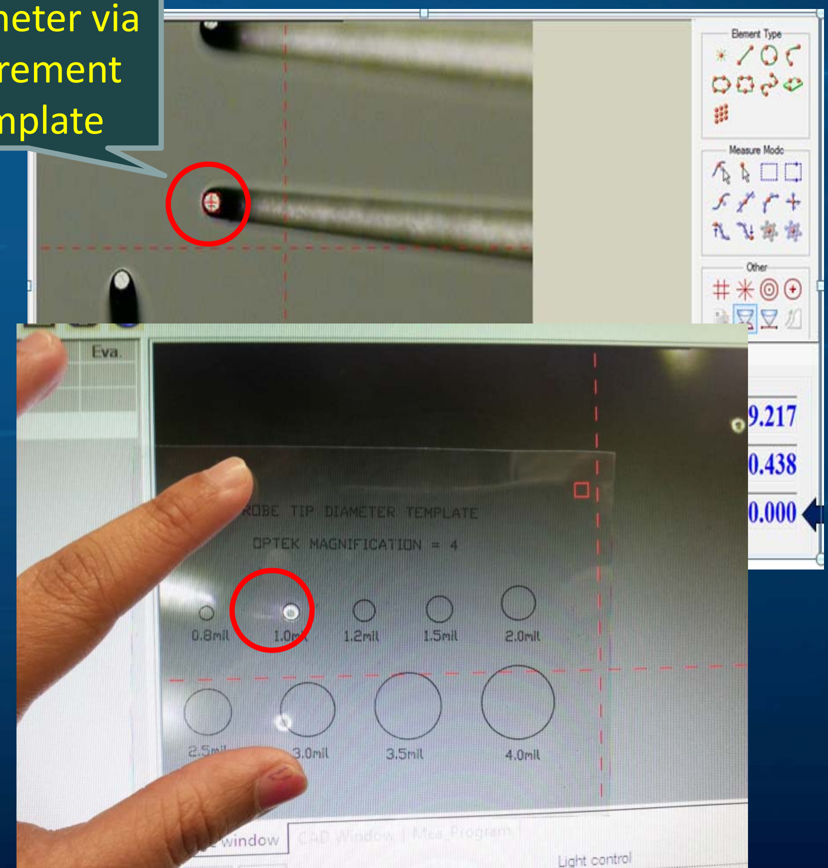
Epoxy clearance

Tip Length

Key Item #6: Unbiased Inspection

- **Issue: disposition inaccurate**
  - based on naked eye and experience, often results in premature rebuild
- **Solution: improve visual inspection procedure**
  - Check tip length and diameter using measurement microscope
  - Use template to measure tip diameter, with clear spec limits

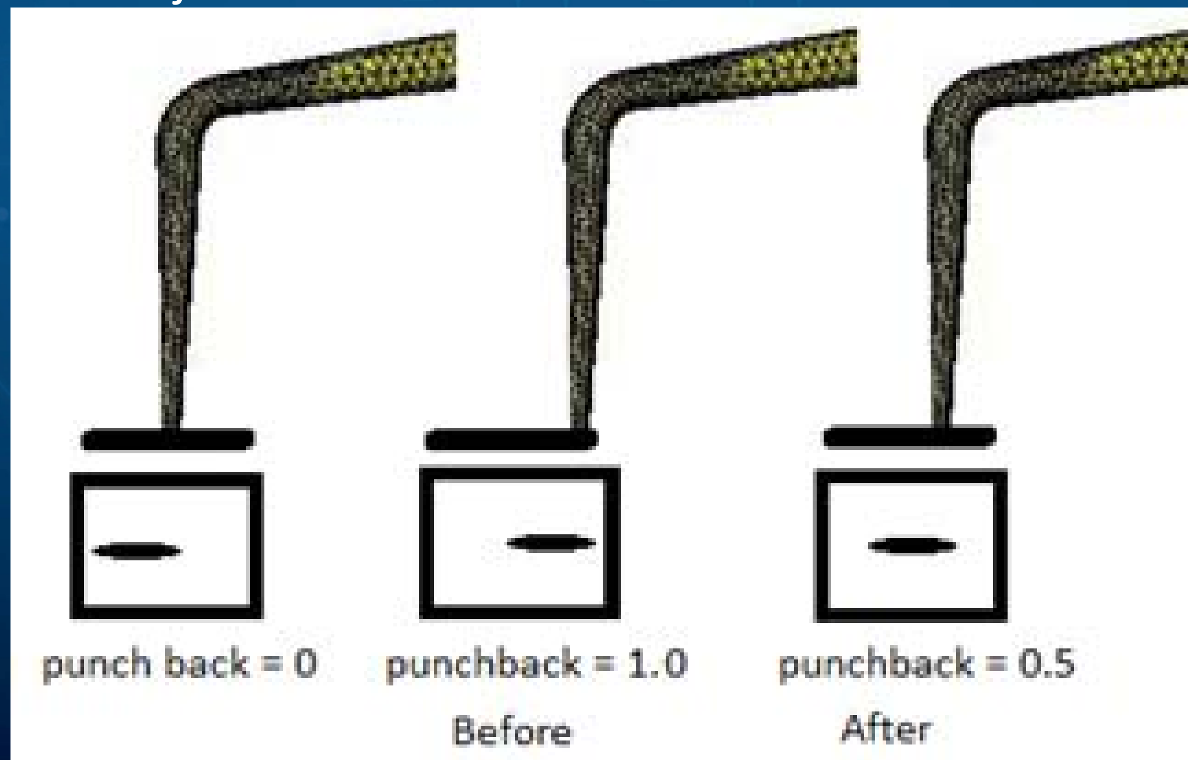




Tip Diameter	Tip Length SP7	Tip Length RT8
before sanding	525um	400um
1mil	450um	360um
1.5mil	350um	260um
2mil	250um	160um - rebuild
2.5mil	150um - rebuild	

Key Item #7: Needle Layout

- **Issue: Probe marks not centered after build**
  - Punch pattern not optimal
- **Solution: Punch data recomputed using 0.5mil punch back as guide for the needle layout**
  - Centers probe mark in the bond pad as built, reducing time for the needle alignment adjustment



Results of Continuous Improvement

Baseline
Epoxy Change
Gel pad reshape
Build Fixture/Tip Length Enhancement
Improve Inpection/ Punch back Optimization

400.00 K
350.00 K
300.00 K
250.00 K
200.00 K
150.00 K
100.00 K
50.00 K
0.00 K

2010
2011
2012
2013
2014

Limitations

- The above improvements are based on the internal design and manufacture of ON Semiconductor probecards. Specific improvements may vary for your application.
  - Tip length optimization always depends upon shaft diameter, desired scrub mark and gram force. Study and experimentation are required.
  - Build fixture depends on the die size and the needle array design. Conical fixture is optimal for some die sizes.
  - Tip length and diameter specifications vary with the application. The inspection method must accommodate all.

Summary

- Touchcount improvement takes time and effort, but can be accomplished
  - Requires data gathering, study, experimentation and lots of qualification work
  - From 75K to 450K average touch counts achieved (6x improvement in probe life)
- Key take aways:
  1. Epoxy quality is important in preventing needle movements (swaying, un-explained alignment issue)
  2. Gel pad is superior for tip reshaping as compared to electrochemical etching
  3. Tip length must be optimized for the application; dependent on the ceramic design. Expose more tip length.
  4. Use an unbiased inspection system to prevent premature rebuild.

Follow-On Work

- **Improve the needle bending process**
  - Optimum needle angle per layer
  - Automated measurement of tip length and angle
  - Ensure uniform bending and placement to prevent the need for further adjustment after build

Acknowledgement

- **Anne-Sophie Lucier : “Preparation and Characterization of Tungsten Tips Suitable for Molecular Electronics Studies”**
- **Gene Humphrey/Rainer Gaggl, Ph.D. : 2004 SWTC workshop “**Extending Cantilevered Probe Card Life”

Questions???