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for production probe cards

How Bad's the Damage?

Evaluating Probe Damage On Aluminum, Solder, Gold, UBM, and Copper Pads.

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Goal of Presentation

- Communicate actual customer experiences with respect to acceptable levels of pad damage. This should help us all set reasonable expectations for probe damage independent of the probe technology being used.

Outline: Issues, Industry status, and proposed operating specs for:

- Aluminum Pads
- Solder Bumps
- Gold Pads
- Gold Bumps
- UBM
- Copper Pads

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Abstract:

- New, thinner metals and softer dielectrics make it important to minimize probe damage and provide reliable evaluation tools. Accurate comparisons of probe damage measurements from different technologies lack a common standard to talk about these parameters. This paper proposes some standard measurement methods for evaluating probe damage, and identifies probing issues on several different customer products.

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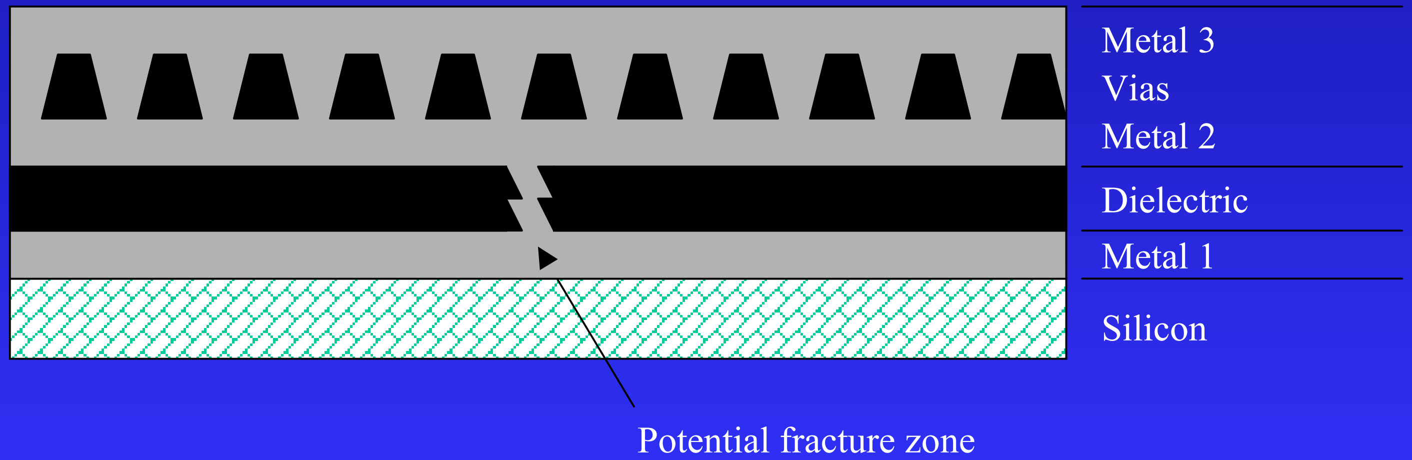
Aluminum pad issues

- Pad thickness moving from 1 micron to 0.7 and 0.5 micron
- Via arrays for CMP processing appear to be increasing the probability of damaging underlying layers



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Suggested probing damage spec for thin aluminum pads with vias over conductors

- Maximum depth less than 80% of pad metal thickness
- Volumetric damage less than 20-50% of total bondable metal volume (bond area x pad metal thickness)
- Pressure (total force / total contact area) less than 10 kpsi (3.5 g / 25 micron dia.)

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Future issues with organic dielectrics

- Yield Strength of common materials (kpsi)

20 – 50	Aluminum alloys
36 – 50	Silicon Nitride
110	Tungsten
12 – 20	Silicon
2 – 8	Organics (10 to 20% as strong)

- *source ASM handbooks

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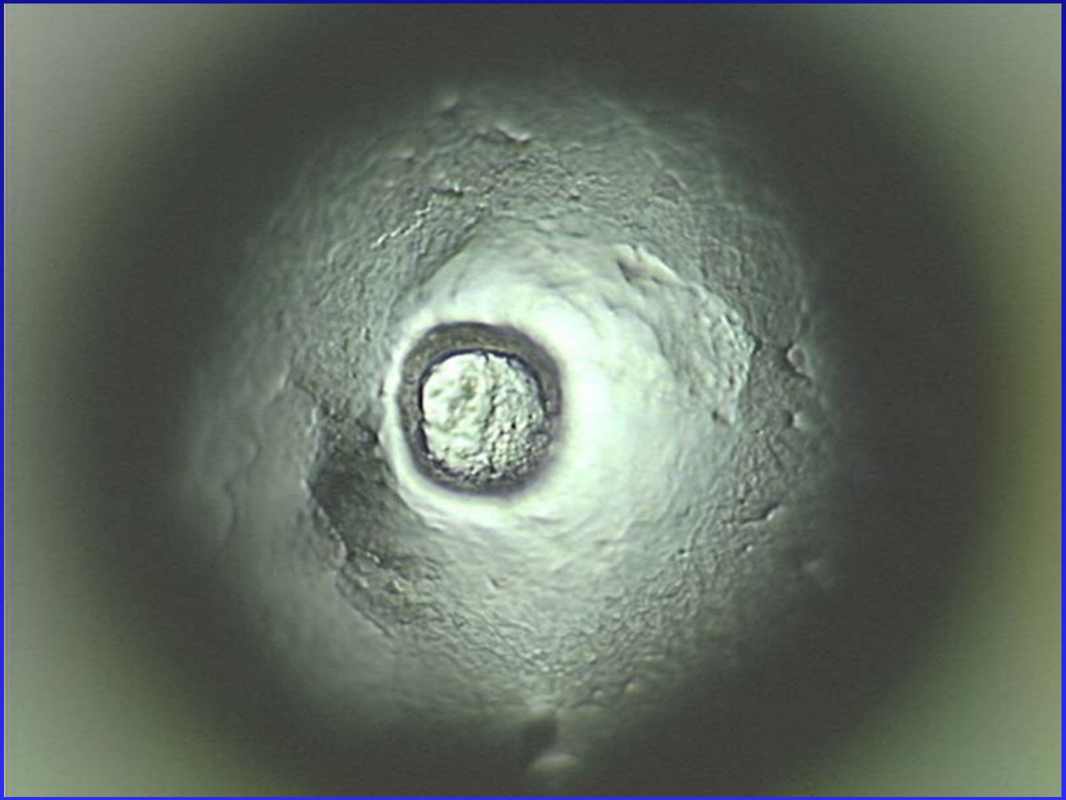
Solder ball deformation issues:

- Possible issues with flux entrapment, solder volume and initial contact with substrate



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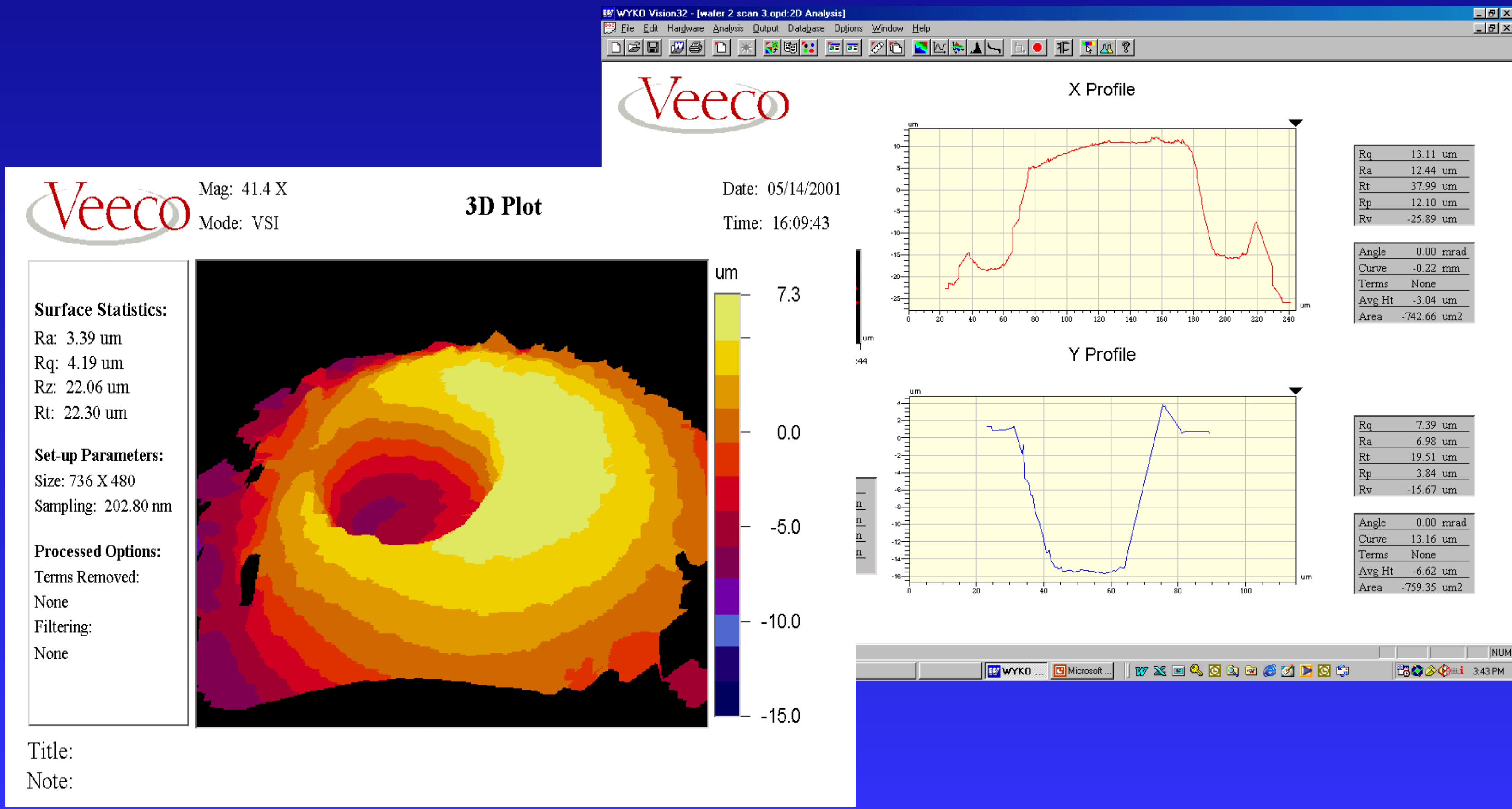
Solder ball probe marks 15 microns deep is working in high volume assembly (spec is 25 um max)



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Other solder bump probing issues

- Solder ball adhesion loss
  - Can cause probe or device damage
  - Most likely due to process problems at solder interface
- Rogue large solder ball
  - Circumstantial evidence suggests they exist and can damage probes

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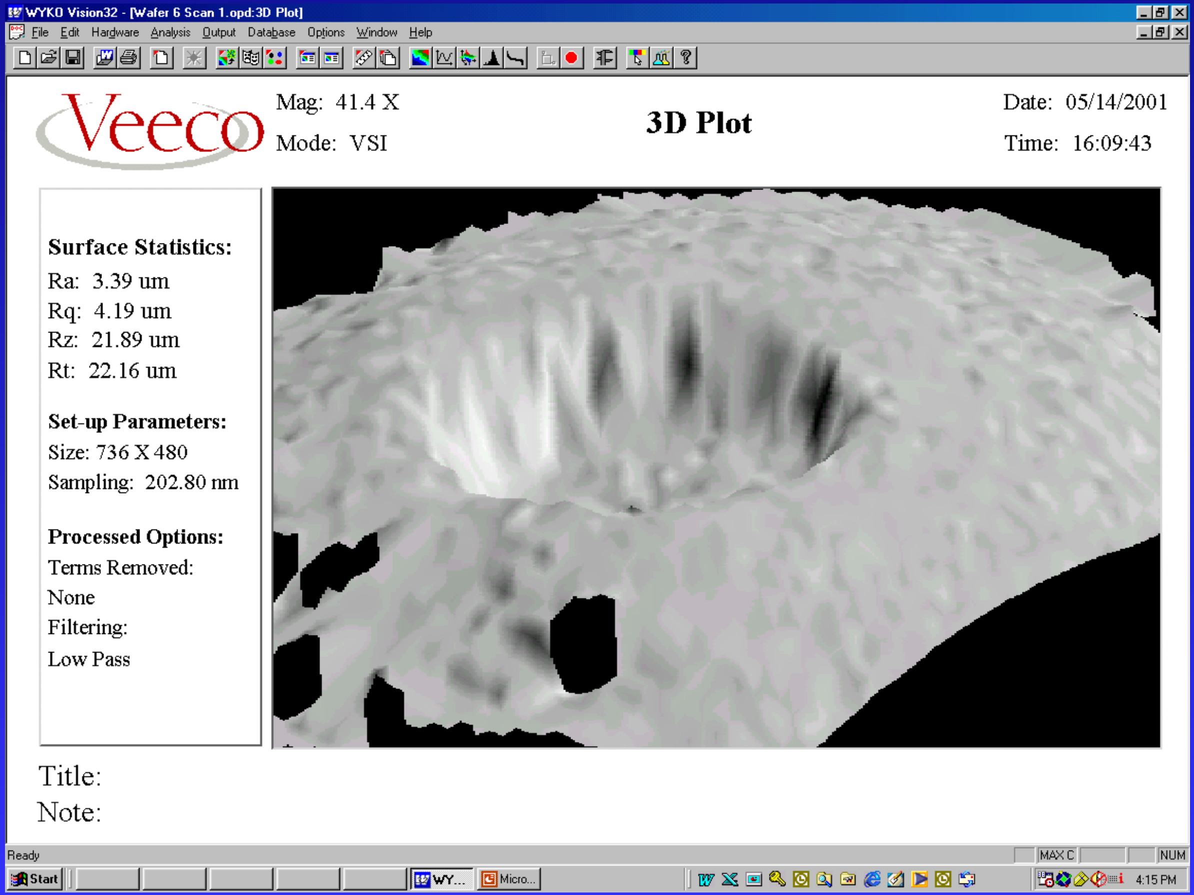
Solder ball surface texture variation is also a challenge for metrology



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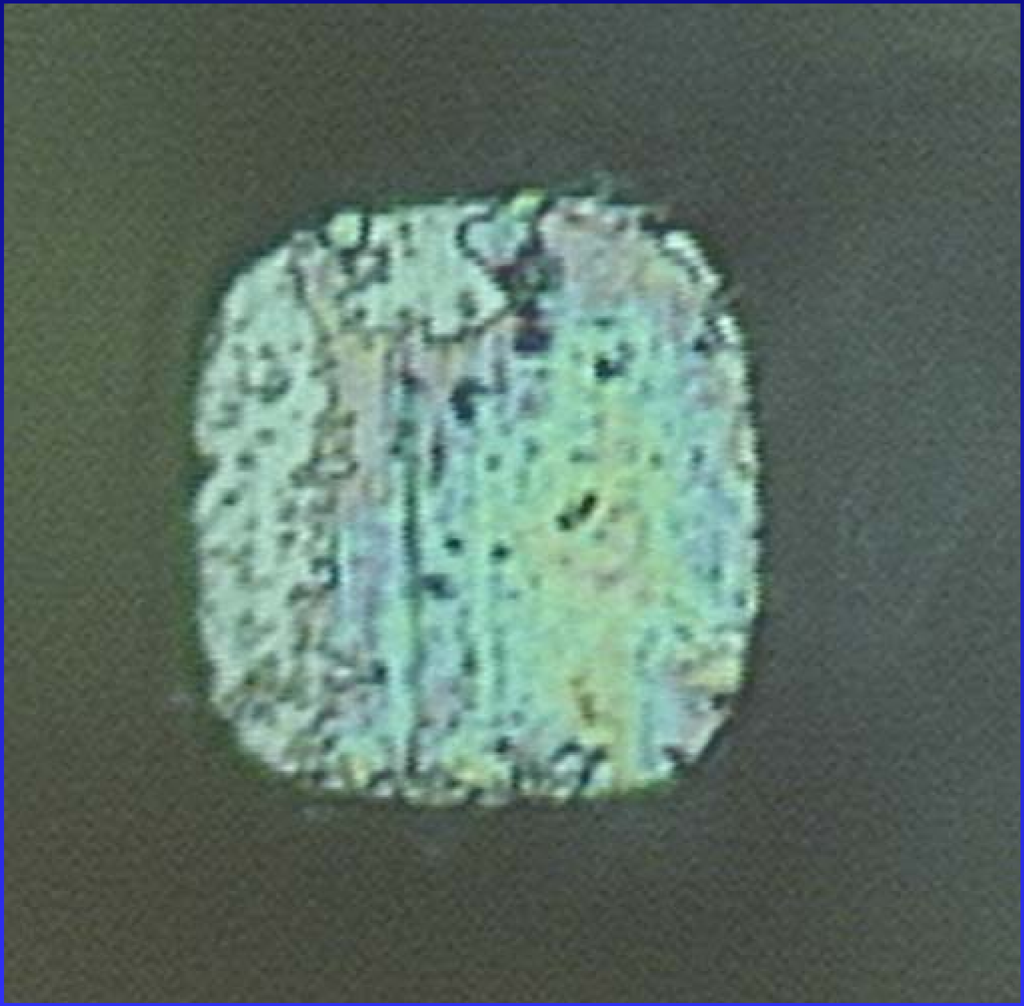
Gold pads are easy…but

- Organic contamination may accumulate or require excess overtravel



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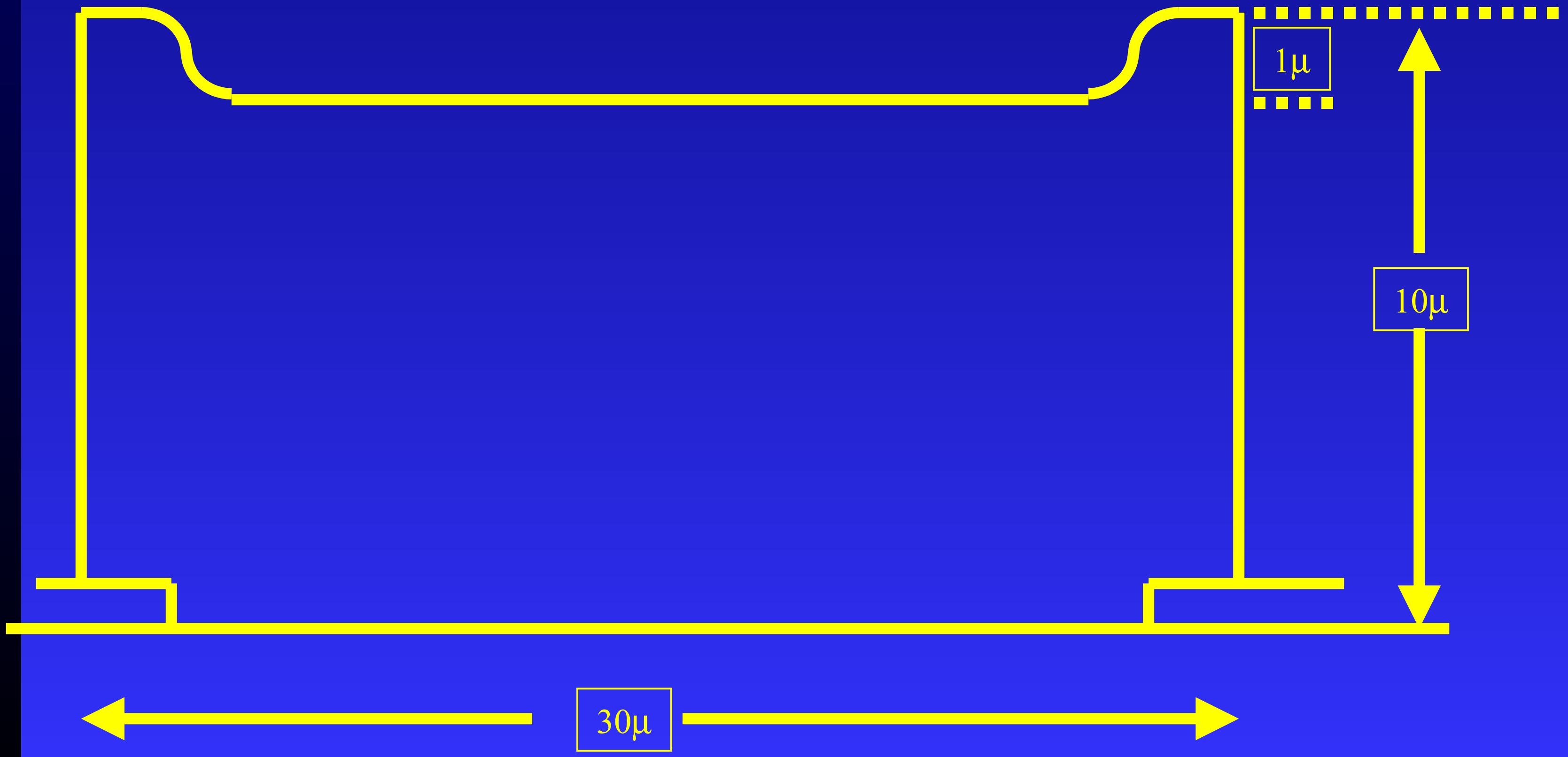
Gold Bumps

- TAB and Direct Chip Attach (DCA) assembly processes require minimal damage to soft gold bumps



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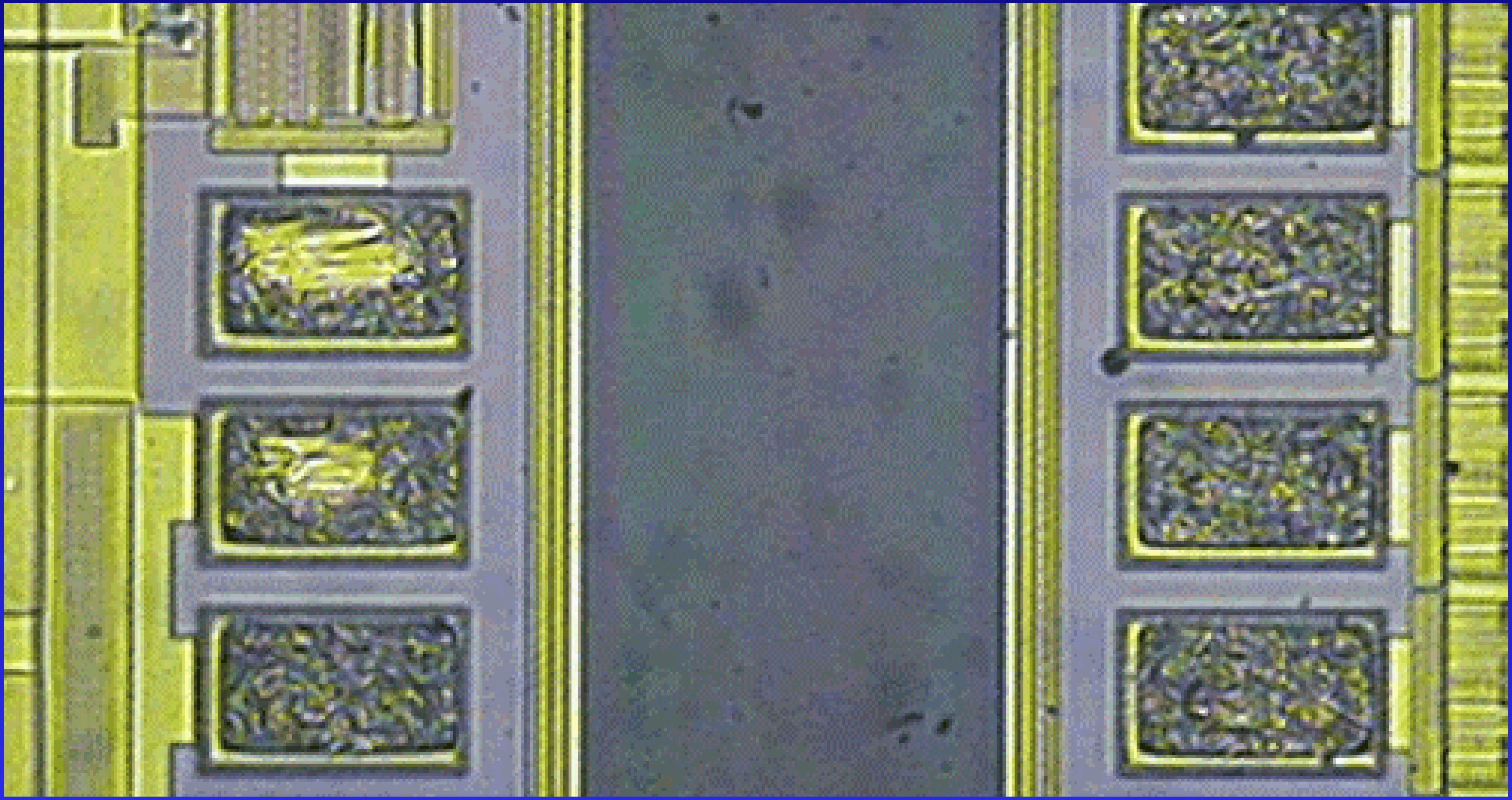
Comparison of cantilever vs Pyramid probe marks



Cantilever

Pyramid

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Under Bump Metal (UBM under solder balls)

- Key probing requirement is to not damage the UBM or barrier metal
  - Preliminary analytical work has shown feasibility
- Status: Not much activity here
- We believe this is viable and appropriate for applications sensitive to contact resistance (especially RF and high speed)

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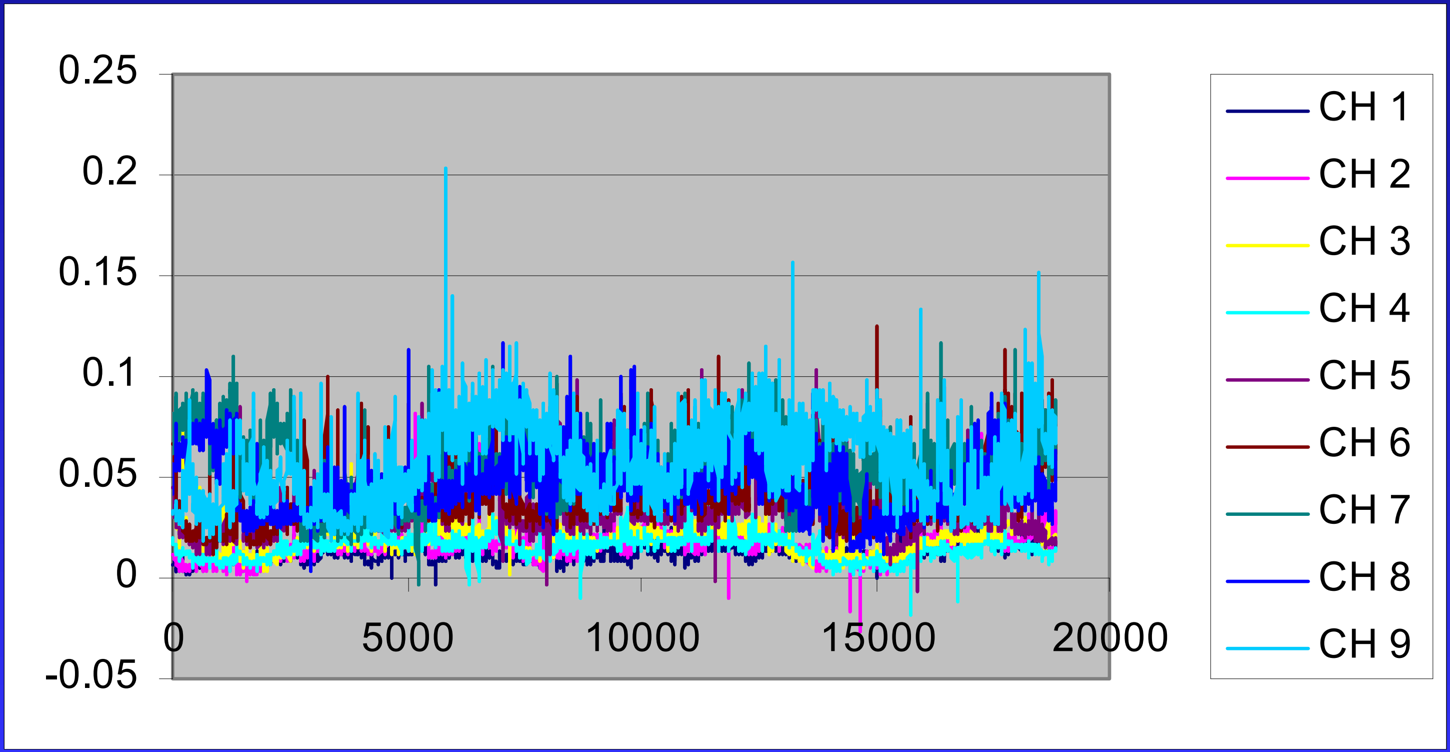
Copper probing issues / status

- Copper oxidizes, is soft, and unlikely to penetrate oxides on tungsten probes
- Pyramid life test data after 90K cycles, no clean, taken at 500 ma, ambient temp



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Major Points

- Aluminum Pads: Thin aluminum, soft dielectrics and structures under pad are creating new probing ~~challenges~~ opportunities
- Solder Bumps: Bump damage doesn't seem to be as much of a problem as the industry expected
- Gold Pads: Organics on gold can be more challenging than expected, especially new dielectrics
- Gold Bumps: Direct chip attach needs < 1 um damage but is achievable
- UBM: Thin UBM and barrier metal are easily damaged. We still think this is the right way to go but don't see much activity
- Copper Pads: Most likely needs non-oxidizing probe tips. Preliminary life test is positive

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