

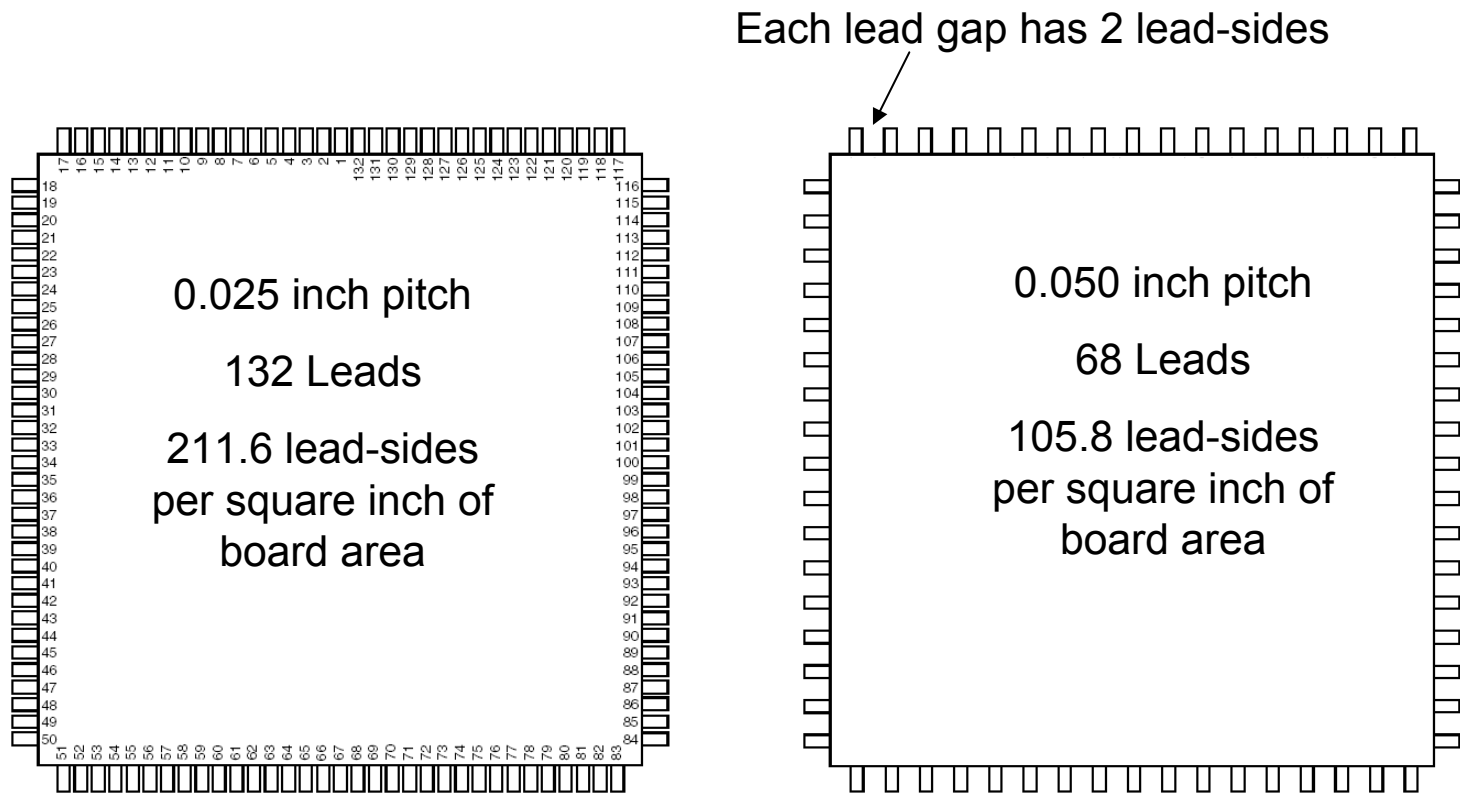
**Lead-to-lead spacing considerations a part of a comprehensive
2B tin whisker mitigation strategy**

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AIA/GEIA/AMC LEAP Meeting

June 10-11, 2008

Risk per square inch



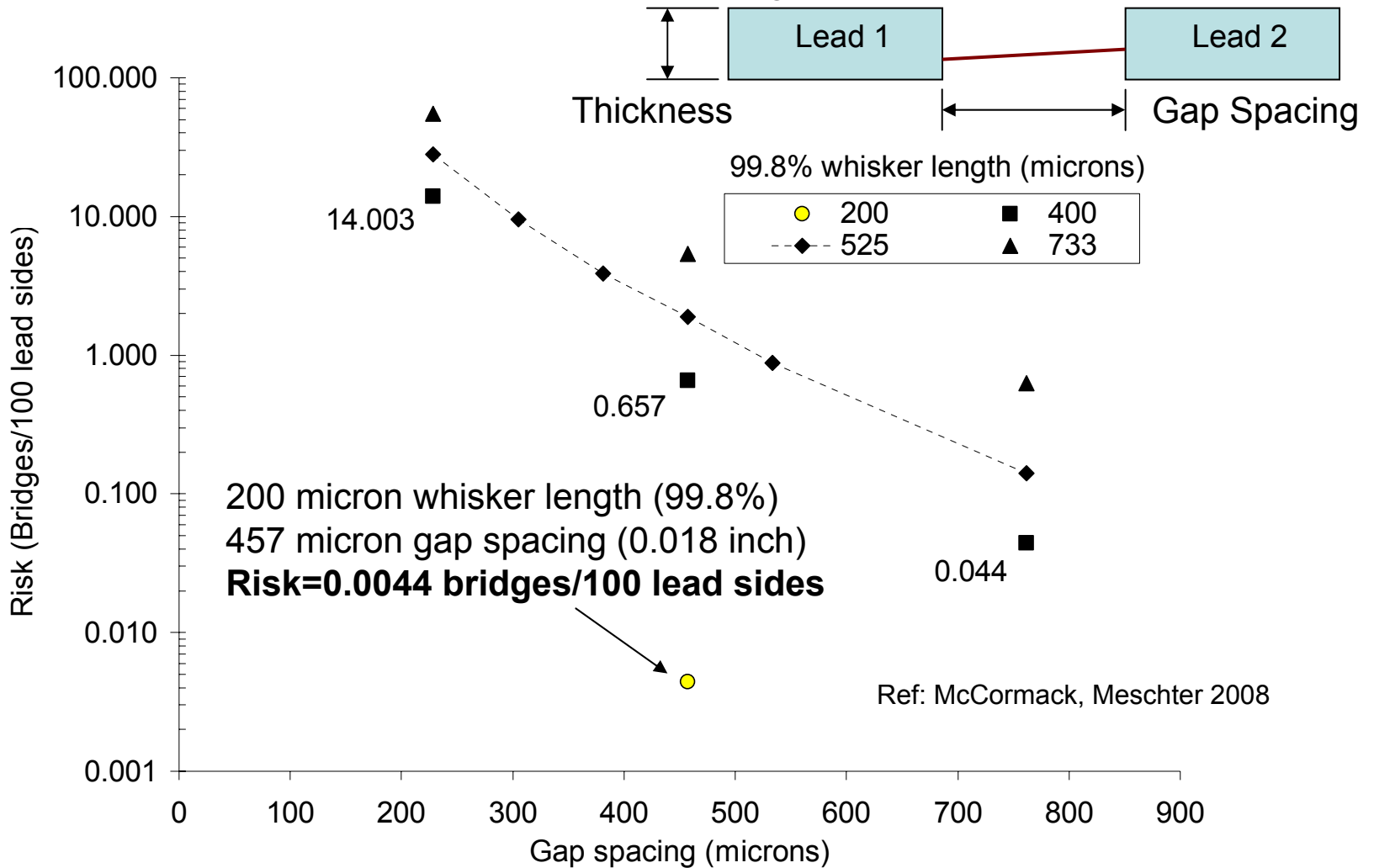
Leads	Lead-Gaps	Lead-Sides	Area (sq inch)	Gaps per sq. inch
132	128	256	1.21	211.6
68	64	128	1.21	105.8

Fine pitch parts have greater numbers of adjacent lead surfaces per unit area of board

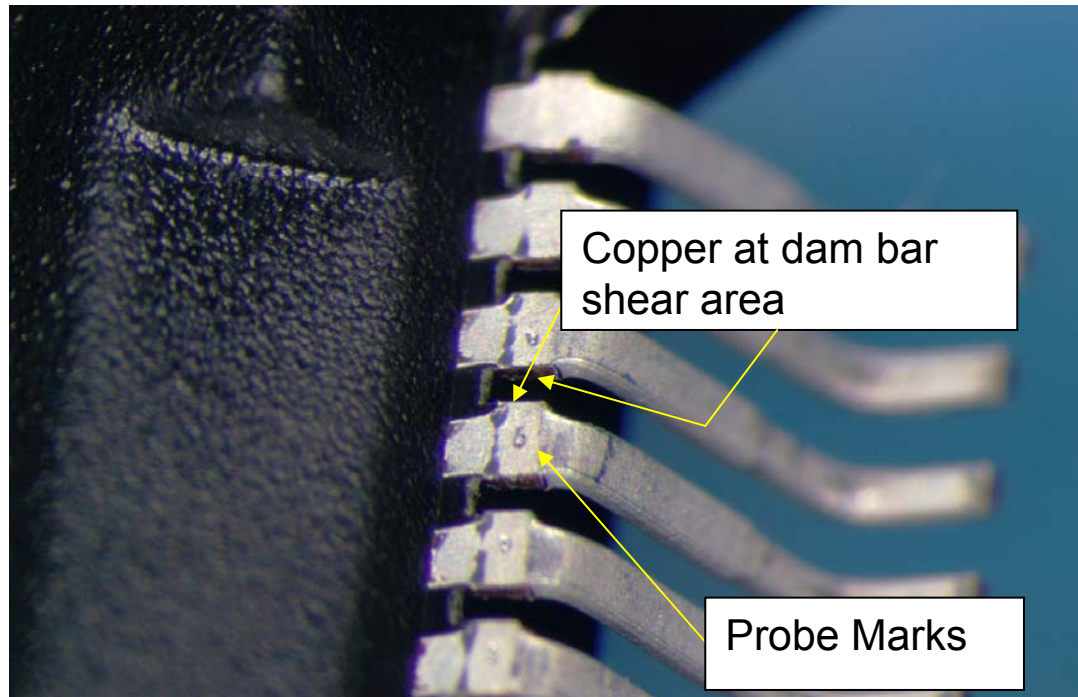
Bridging risk simulation – one side of a lead to its neighbor

Monte Carlo bridging risk analysis

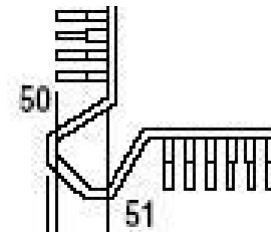
Lead thickness = 152 microns (0.006 inch), Length = 1016 microns (0.040 inch)



Fine pitch device leads – many features



Dam bar not readily apparent in drawing



8. DIMENSION F DOES NOT INCLUDE DAMBAR PROTRUSIONS. DAMBAR PROTRUSION SHALL NOT CAUSE THE LEAD WIDTH TO EXCEED 0.019.

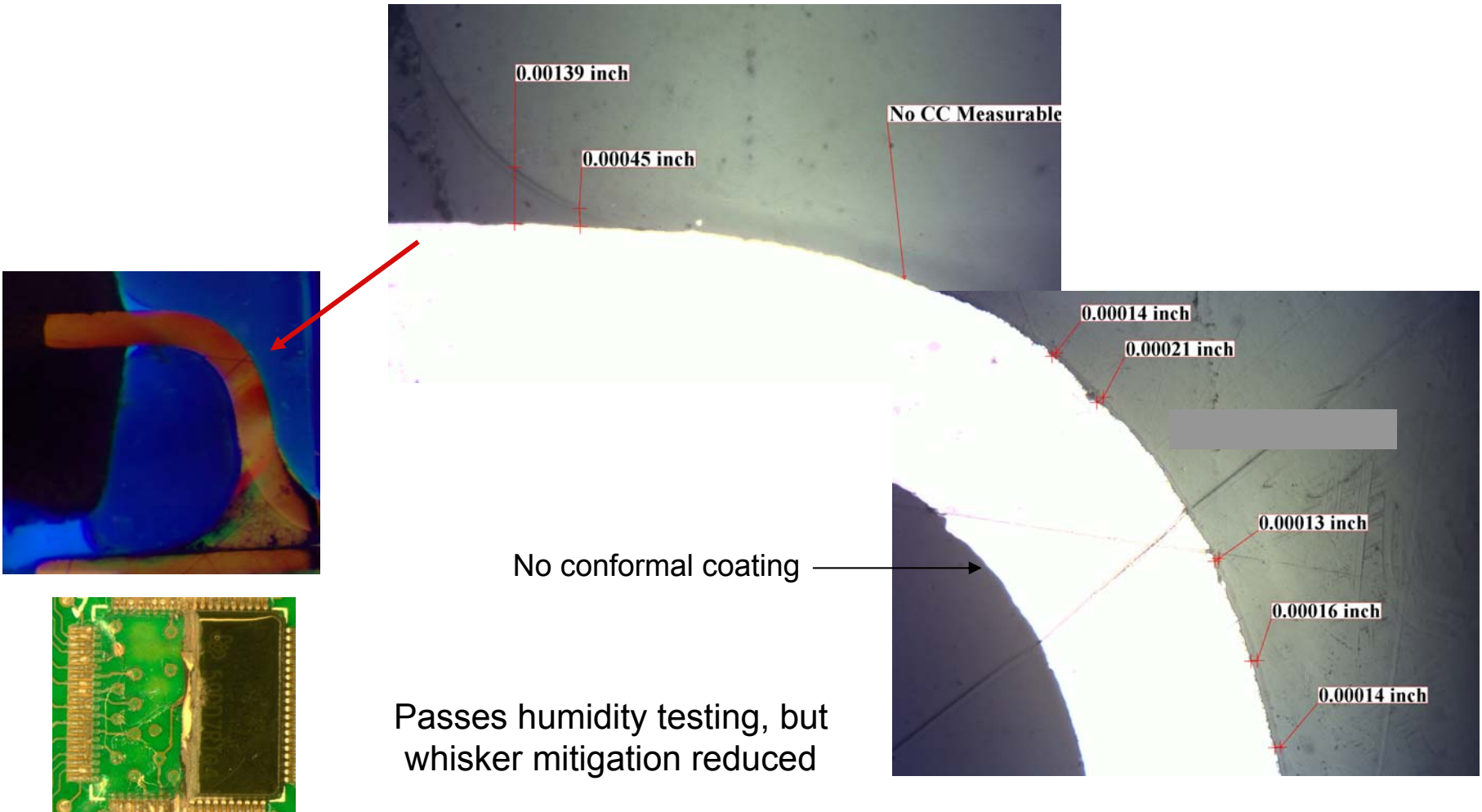
Small tin/copper dis-similar metal region has increased whisker propensity

- Minimum spacing as low as 152.4 microns, 0.006 inches (for 0.025 inch pitch part above)
- Tough to coat sharp corners with conformal coating

Probe marks after soldering are sources of compressive stress contributing to whisker growth

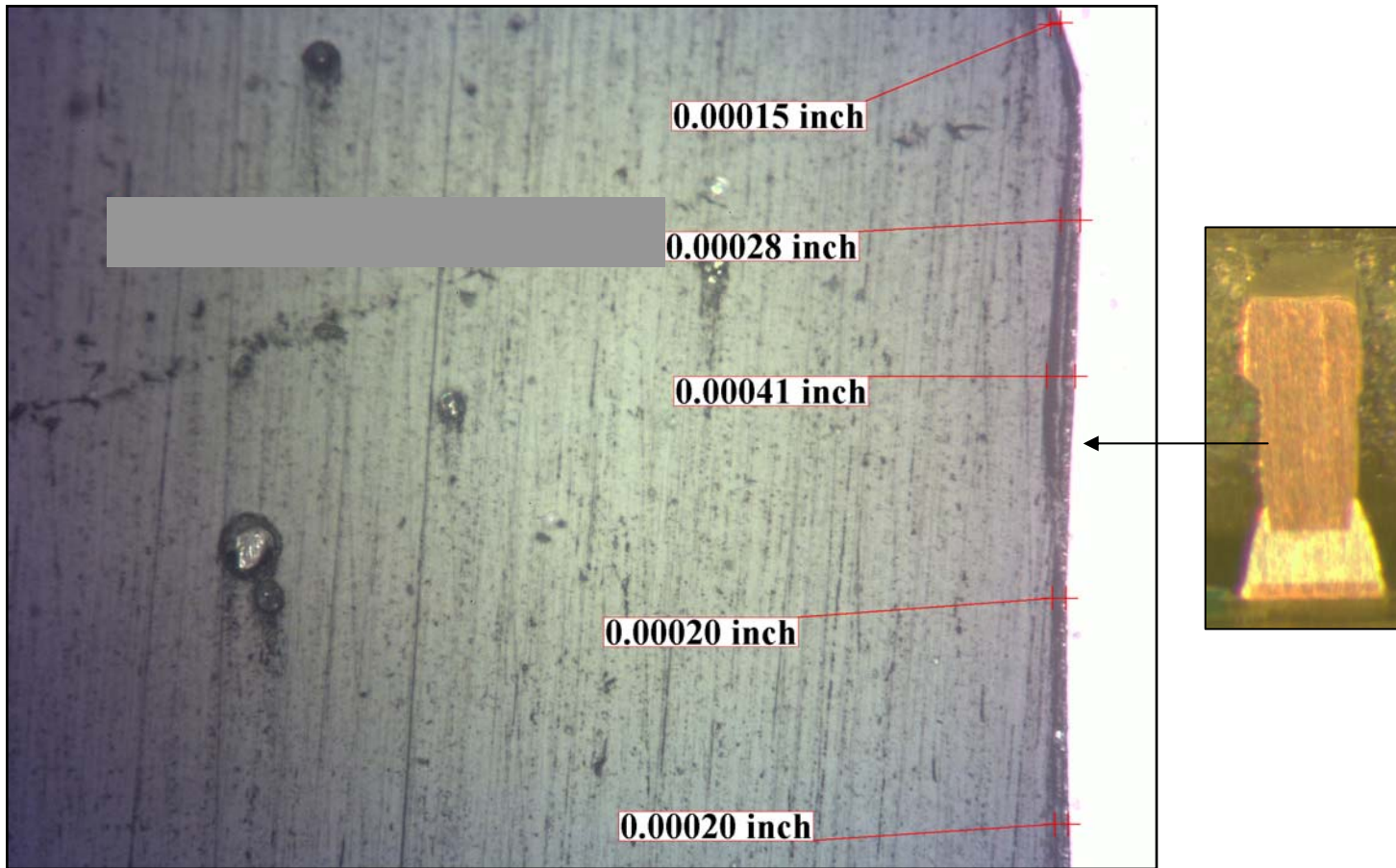
- Same on any part, just closer together on a fine pitch part

Conformal coat coverage - urethane coating A



**Coating thickness can be variable depending upon geometry and wetting
Higher viscosity coatings increase thickness but increase bridging tendency.**

Conformal coat coverage - acrylic coating A



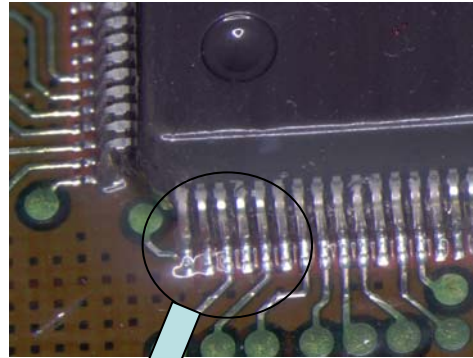
Need cross-section to measure coating thickness

Coating can become thin on sides of part

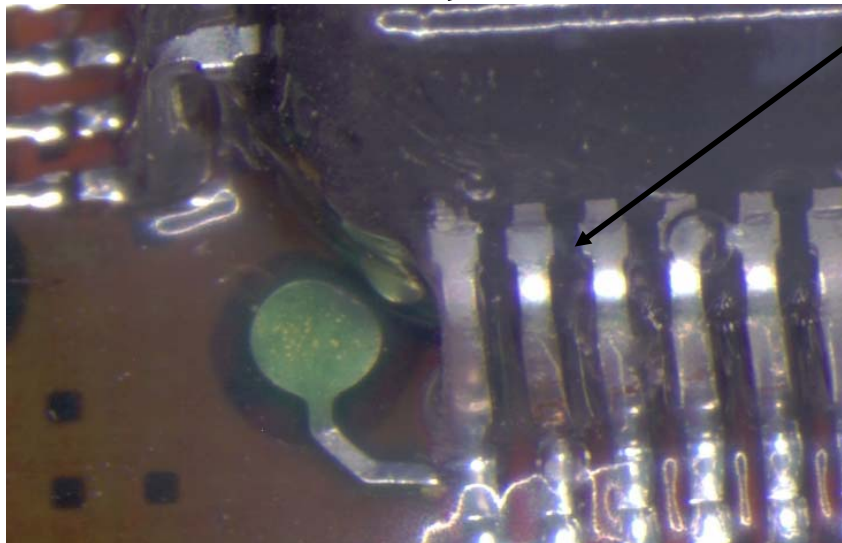
Ref: Richardson, M. 2007

Conformal coat bridging between fine pitch leads – silicone coating

Thicker conformal coating can tend to bridge between leads



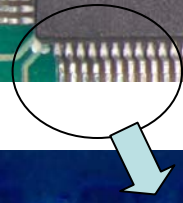
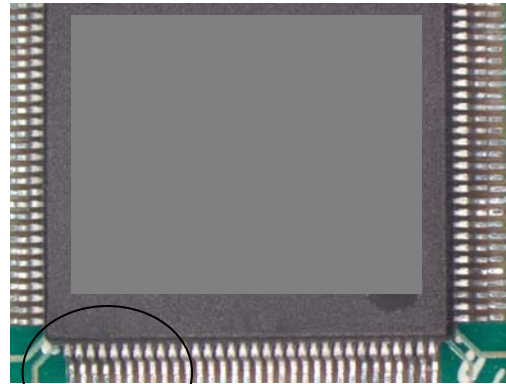
- Whiskers can grow into and be supported by coating (1).
- Difficult to perform whisker remediation and cleaning



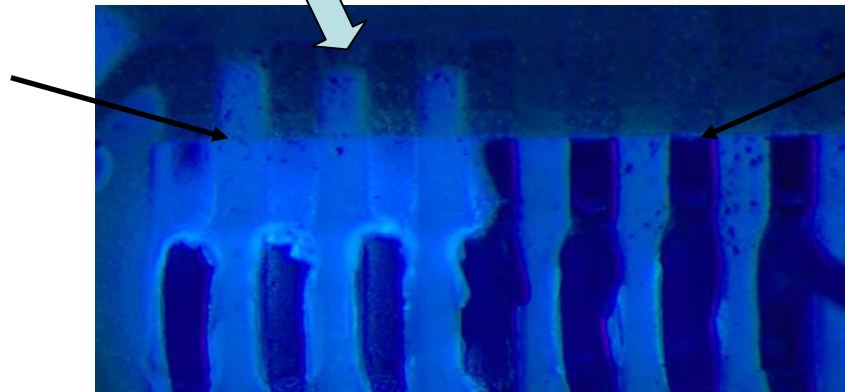
Ref. (1) Richardson, J.H., and Lasley, B.R., "Tin Whisker Initiated Vacuum Metal Arcing in Spacecraft Electronics", Proceedings of the Government Microcircuit Applications Conference, Vol. 18, pp. 119 - 122, November 10 - 12, 1992.

Conformal coat coverage of fine pitch devices – spray coat shadowing

Fine pitch device



PWB pads
behind leads
covered by
coating



Behind leads - PWB pads
not coated
Difficult to inspect

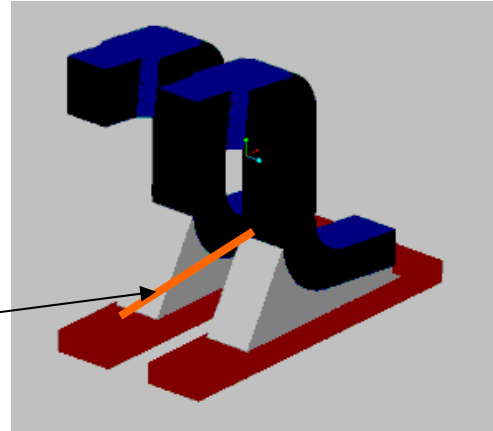
Ultraviolet light illuminated view of pads
with leads and package removed

Whisker shorting distances – back side of lead

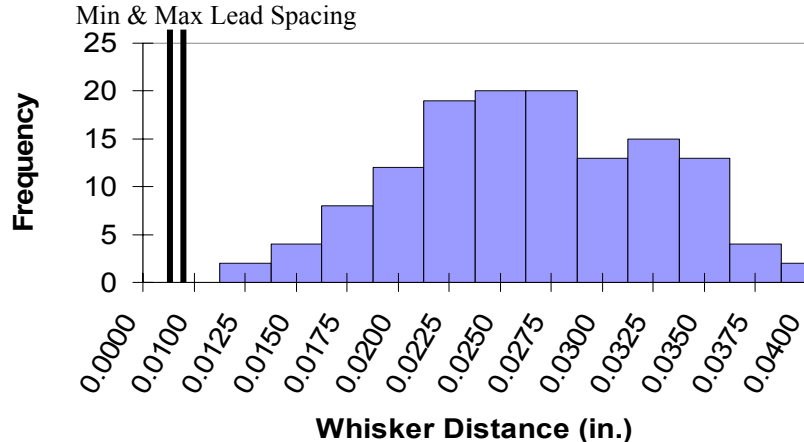
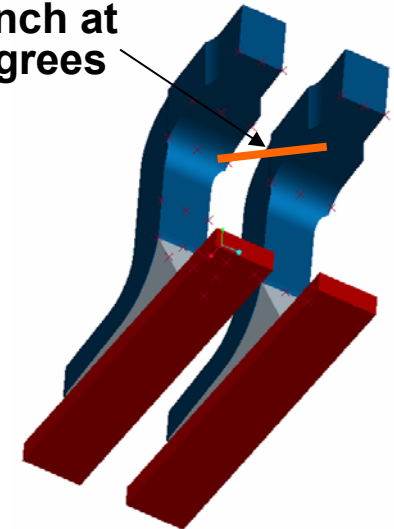
Back side risk study: One set of data

Pitch	Package Thickness	Minimum Lead Spacing
0.0157	0.0630	0.0087
0.0250	0.1700	0.0090
0.0500	0.0950	0.0180

0.021 inch at 31 degrees



0.012 inch at 9.6 degrees



Little/no conformal coat on back side of lead (spray conf coat process).

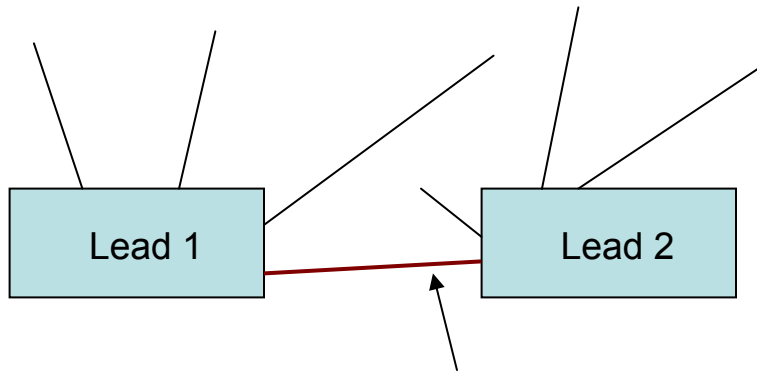
Can't take credit for CC attenuating whisker growth.

Can't take credit for CC providing dielectric protection.

What about whisker to whisker interaction?

Ref: Olenik BAE Systems 2007 (unpublished)

Whisker buckling



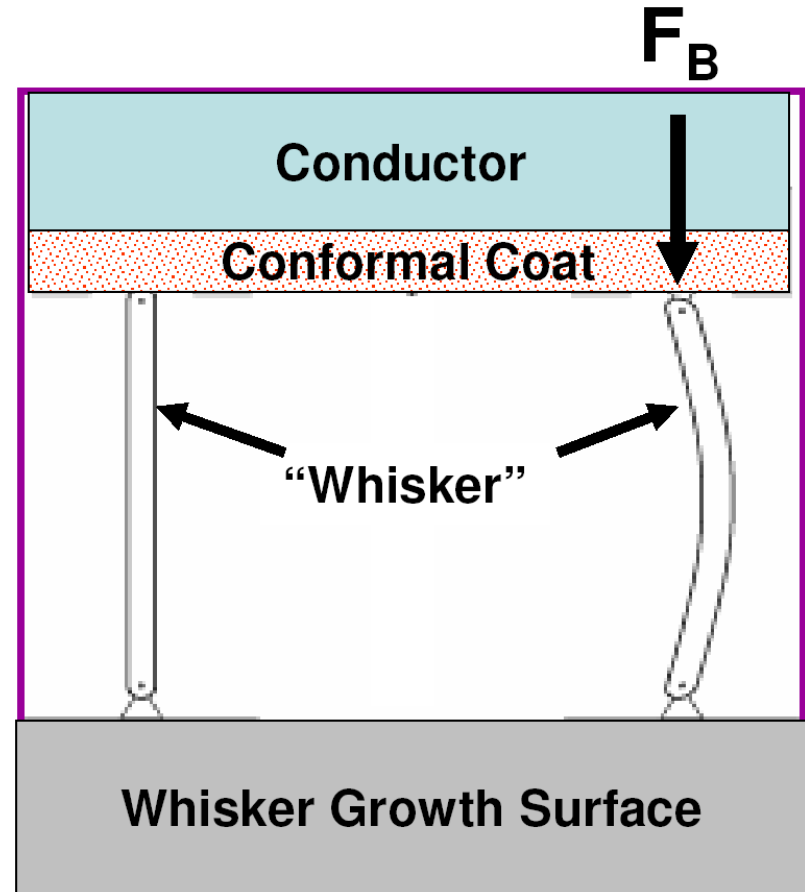
Tin whisker bridging between adjacent leads.

If whisker buckles before
penetrating adjacent
conformal coated surface
- NO electrical short

Ref: Jay Brusse, Dr. Henning Leidecker, Lyudmyla Panashchenko, "Metal Whiskers: Failure Modes and Mitigation Strategies", Microelectronics Reliability and Qualification Workshop, December 5, 2007.

<http://nepp.nasa.gov/whisker>

McKeown, Kane, Meschter, "Whisker Penetration Into Conformal Coating", Proceedings IPC APEX 2007

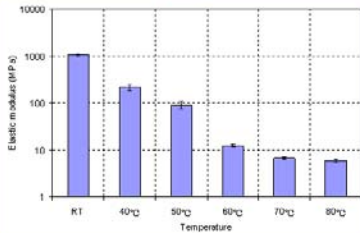


Whisker buckling – coating softening with temperature

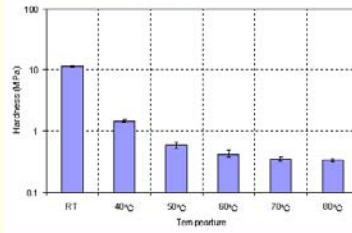
Nanoindentation on Acrylic Coating: Effect of Temperatures

by Dr. Junghyun Cho's group (Binghamton University) Jan. 4, 2007

Elastic modulus (GPa)

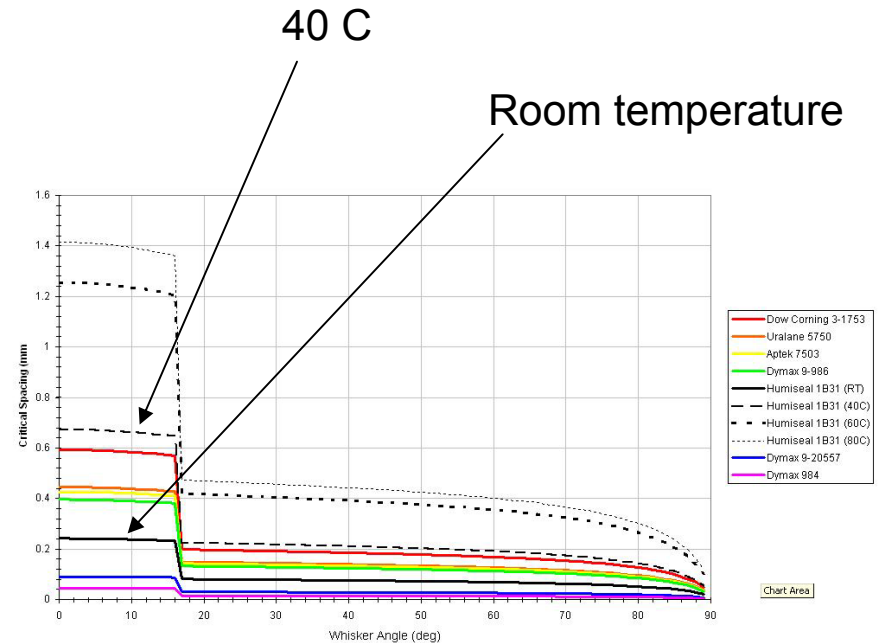


Hardness (MPa)



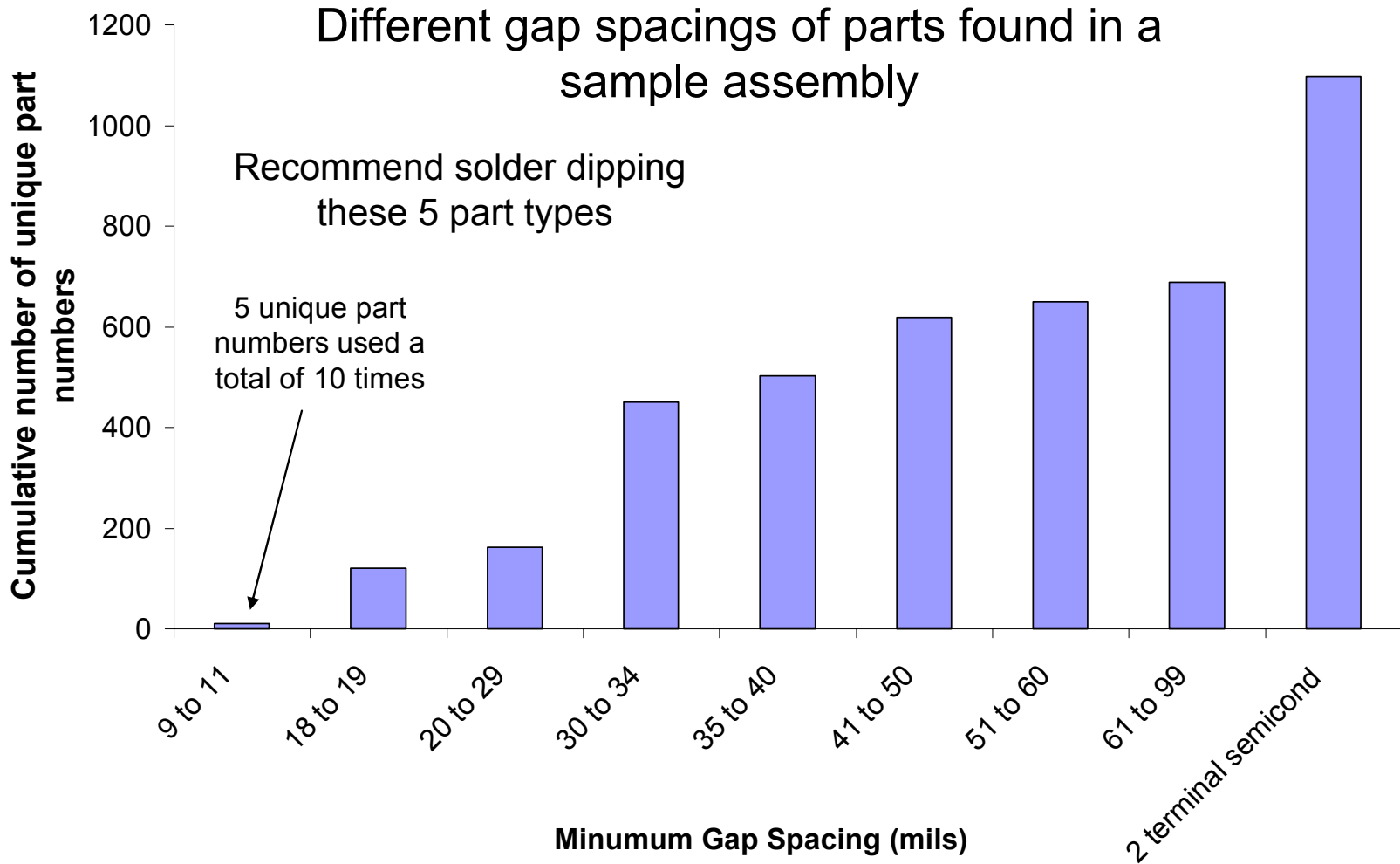
- Overall Elastic modulus (E) and Hardness (H) at room temperature (RT)
 $\rightarrow E = 1.05 \text{ GPa} (\pm 0.05), H = 11.6 \text{ MPa} (\pm 0.31)$
- Averaged from 3 indentations
- Average indentation depth (h_{max}) = $\sim 3 \mu\text{m}$

Acrylic softening results in a significant increase in re-penetration risk at 40 C



McKeown BAE Systems 2007
(unpublished)

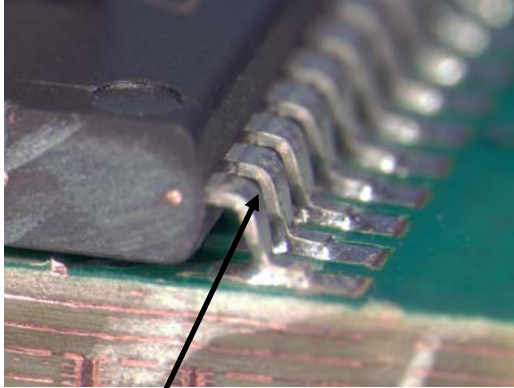
Part mix - spacing



A small number of parts have highest bridging risk:
 0.018 inch spacing is a natural break point in the demographics

Greater gap spacing between leads – 18 mil spacing, 50 mil pitch

50 mil pitch part



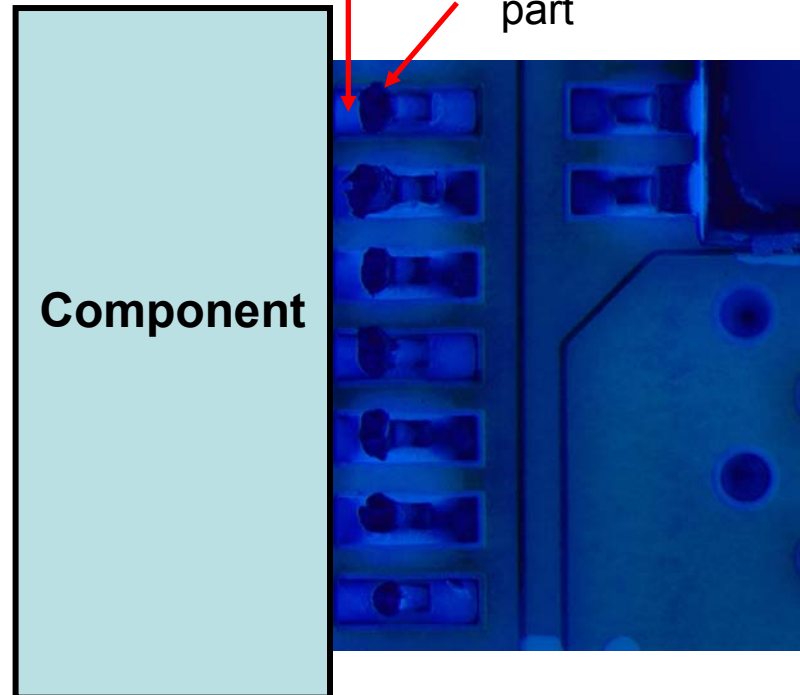
No dam bar shear area on larger pitch parts

No conformal coat bridging between leads

Longer whisker more likely to be bent or kinked (more likely to buckle)

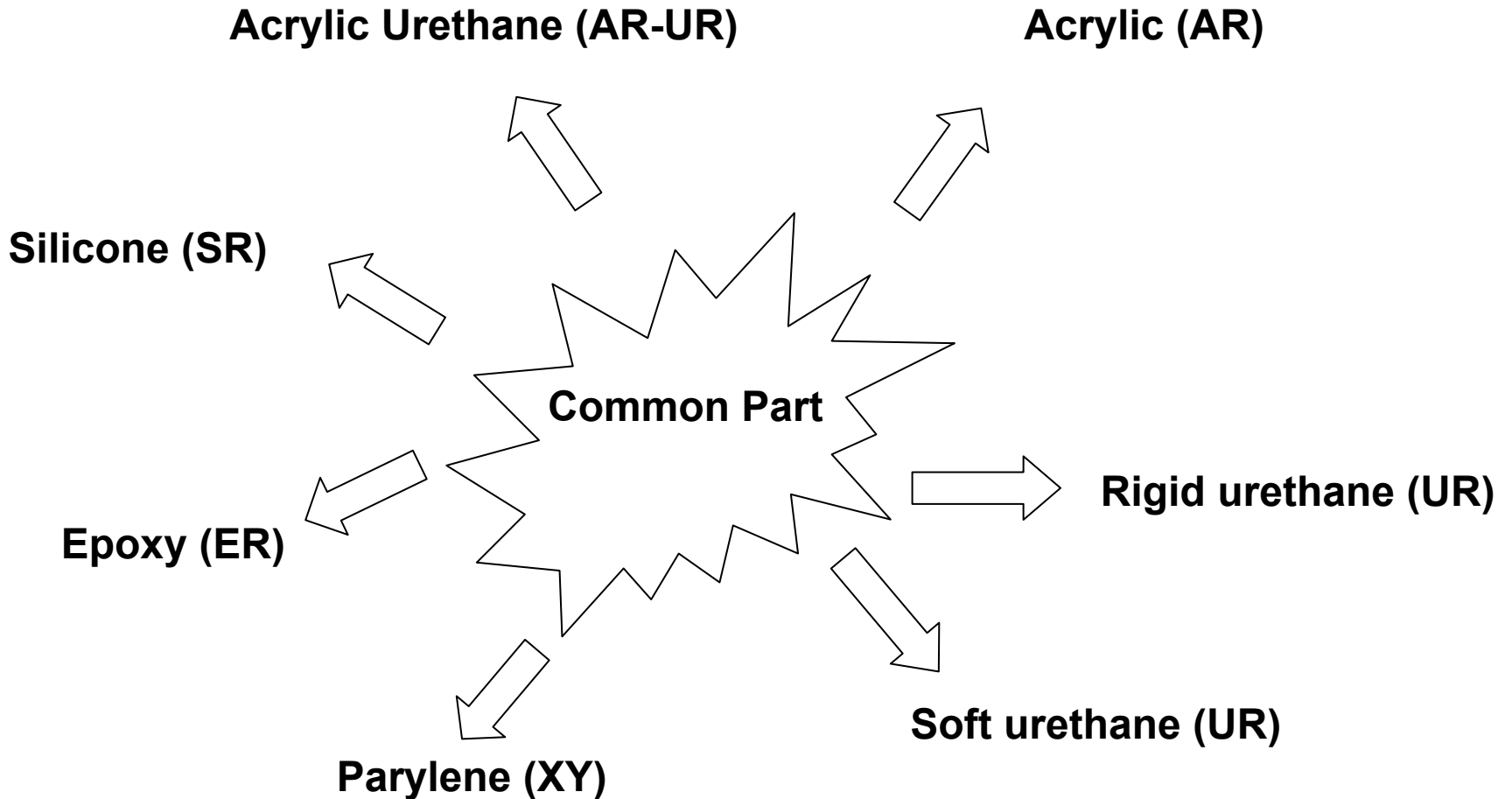
Good conformal coat spray coverage of PWB pads behind leads

During examination, leads snipped to remove part



Ultraviolet light illuminated view of pads with leads and package removed

Conformal coat – Common part on many assemblies



Not all coatings created equal: same part, multiple usages

Close gap spacing versus larger spacing

Less than 18 mil separation

Parts with smaller lead spacing yield more bridging opportunities per square inch of PWB area – more risk

Smaller gaps – increased bridging risk

- Shorter time for whisker to bridge gap
- Less likely to buckle on adjacent CC
 - Expect only hard CCs likely buckle whiskers

More challenging to conformal coat (CC)

- Less coverage on printed wire board pads behind leads
- CC more likely to bridge between leads and support bridging whiskers

Corrosion induced whisker risk higher

- Dam bar shear dis-similar metal corrosion sites

18 mil or greater separation

Parts with greater lead spacing yield fewer bridging opportunities per square inch of PWB area – less risk

Larger gaps – decreased bridging risk

- Longer time for whisker to bridge gap
- More likely to buckle on adjacent CC
 - Can tolerate more CC coating types and hardness variations

Better conformal coat (CC) whisker mitigation

- Better CC coverage on PWB pads behind leads
- CC less likely to bridge between leads so CC will not be able to support bridging whiskers
- Corrosion induced whisker risk lower
 - Devices with larger lead separation typically don't have dam bar shear areas

Strategy allows experience to be gained with both hot solder dipped and Tin finished part performance

Summary

- Not all conformal coatings created equal
 - No defined requirements for conformal coating when used as a tin whisker mitigation
- Risk decreases as spacing increases
- There is a natural break at .018" spacing base on components utilized in electronic assembly
 - 0.018 inch spacing or greater CC is an adequate mitigation.
 - Less than 0.018 inch spacing needs to have additional mitigation besides conformal coat.
- Recommendation is to hot solder dip components with less than 0.018 inch spacing
- This position will be modified as additional data warrants