

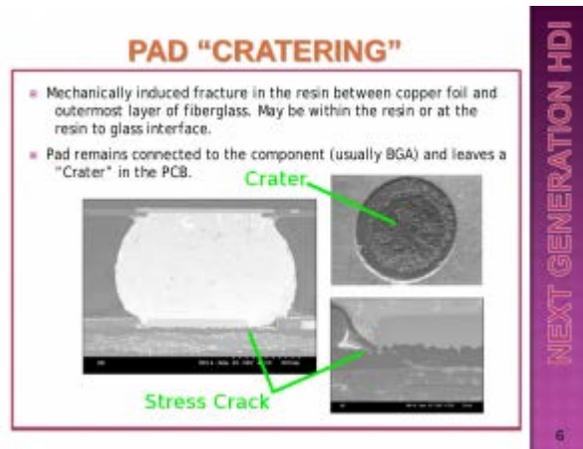
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Title:
Pad Cratering

Executive Summary:

Lead-free assembly has introduced many challenges and non-conformances. One of the more troubling non-conformances is "Pad Cratering". Pad cratering is when the copper pad completely separates from the laminate. The separation may occur outright at assembly or as the result of the field failure scenario detailed above. Pad cratering is the result of the technology exceeding the capabilities of the materials.



Example of pad cratering provided by Integral Technology.

To date there has been no solution to the problem of pad cratering, until now. Integral Technology has developed a solution that has the potential to minimize if not eliminate pad cratering. Integral's solution is a material called Zeta Cap®. Zeta Cap® is a high performance polymer film that is capable of withstanding high temperatures. It has no woven fiber-glass thus making it CAF resistant. It can be used in combination with current technology as an additional material layer between the outer layer foil and outer most dielectric. Zeta® has a high mechanical strength and flexibility compared to other lead-free compliant laminate materials.

Integral Technology's Zeta® Lam, Zeta® Bond and Zeta® Cap (patents pending) are breakthrough materials for the PCB industry. The portfolio of Zeta products was spawned as a direct result of conversations with OEM's and suppliers about how to expand product lines and solve problems. The original idea was to solve the problem of pad cratering (http://en.wikipedia.org/wiki/Pad_cratering). This silent and increasing threat to the electronics business can be eliminated by using Zeta® Cap on the PCB. The industry is enthusiastically embracing Zeta® Cap and its growth in the marketplace is a direct result of all stakeholders focusing on a solution to an emerging industry problem.

Integral has evolved the product portfolio from Zeta® Cap alone to include Zeta® Lam and Zeta® Bond, giving Zeta customers' new opportunities with High Density Interconnects. Zeta® Cap, Zeta® Lam, and Zeta® Bond are fiberglass free laminate and bonding materials that meet the needs of the next generation of electrical, mechanical and thermal demands due to the fact they are thin, high Tg, Low Dk and Low Df materials.

Pad Cratering On PCB's



What is Pad Cratering?

- IPC-9708
 - **1.2.4 Pad Cratering** “The formation of a cohesive (or adhesive) dielectric crack or fracture underneath the pad of a surface mount component, most commonly BGA packages.”

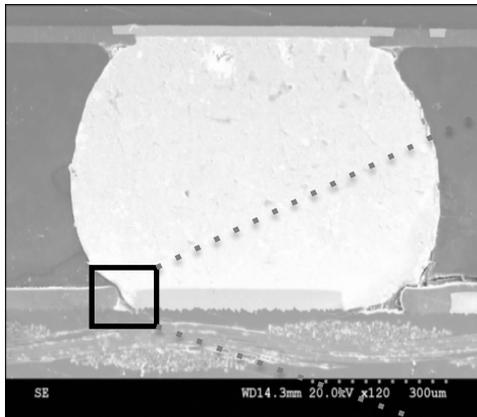


Figure 1

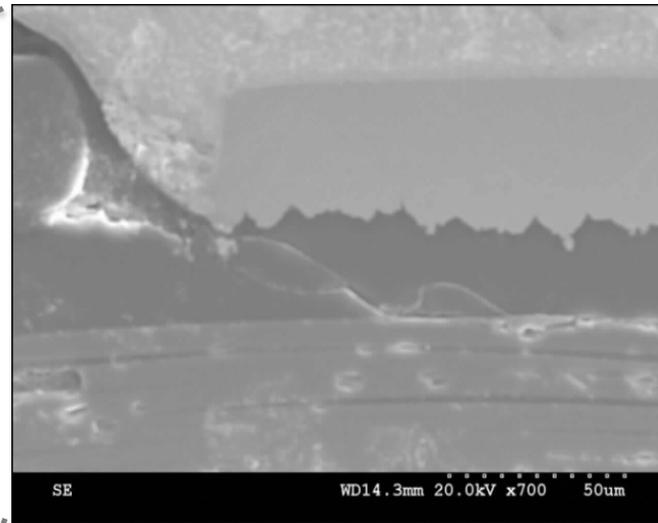
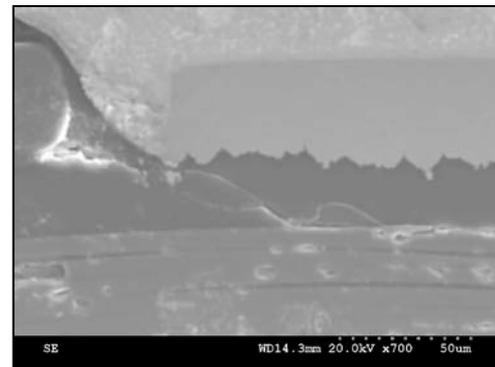
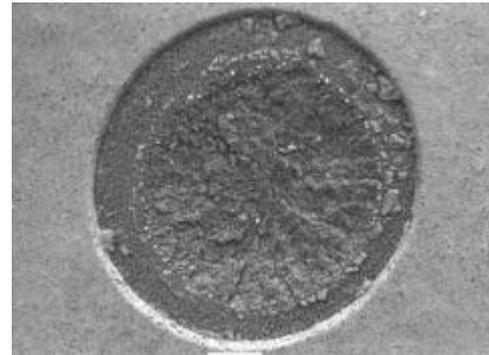
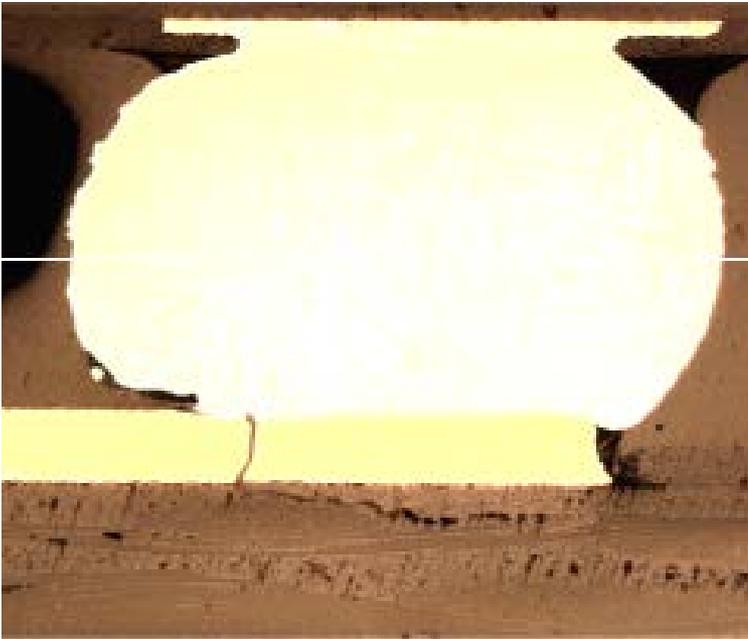


Figure 2

PAD “CRATERING”

- Mechanical in nature, but may be thermally induced.
- Popular lead free solder compatible materials tend to be more brittle.

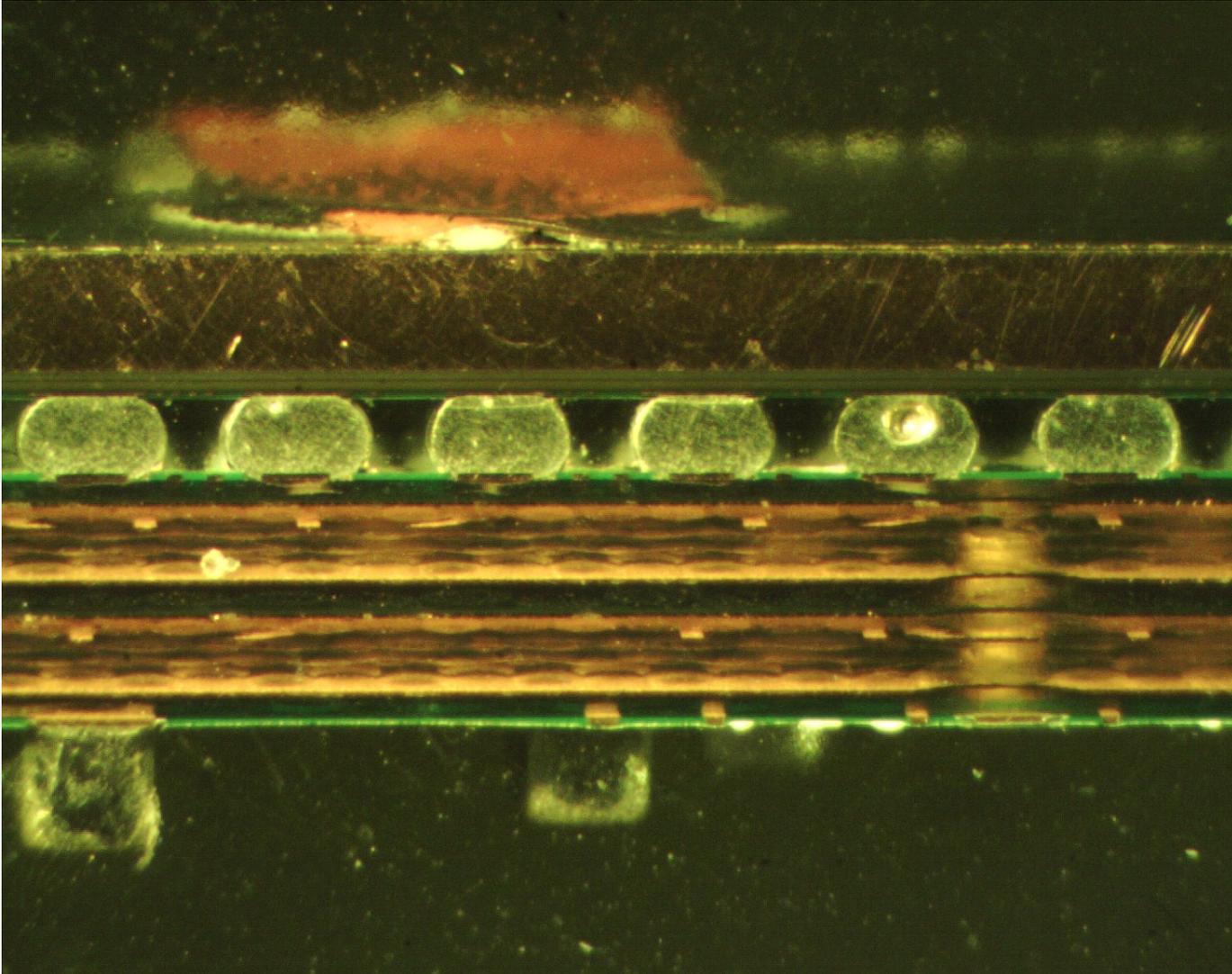


Pad Cratering... Opens Circuits

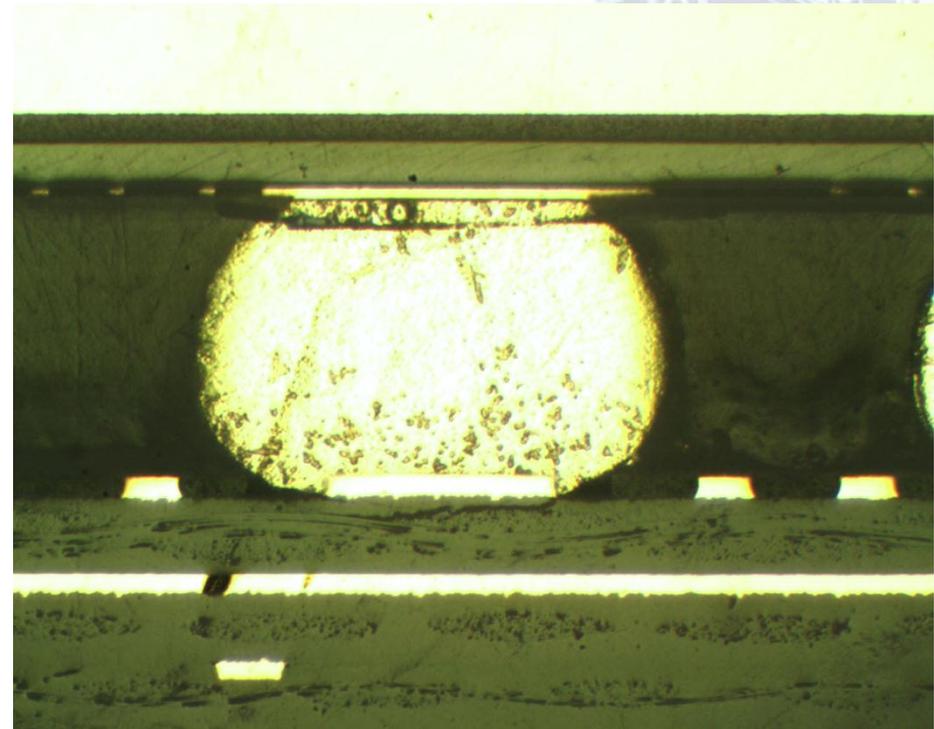
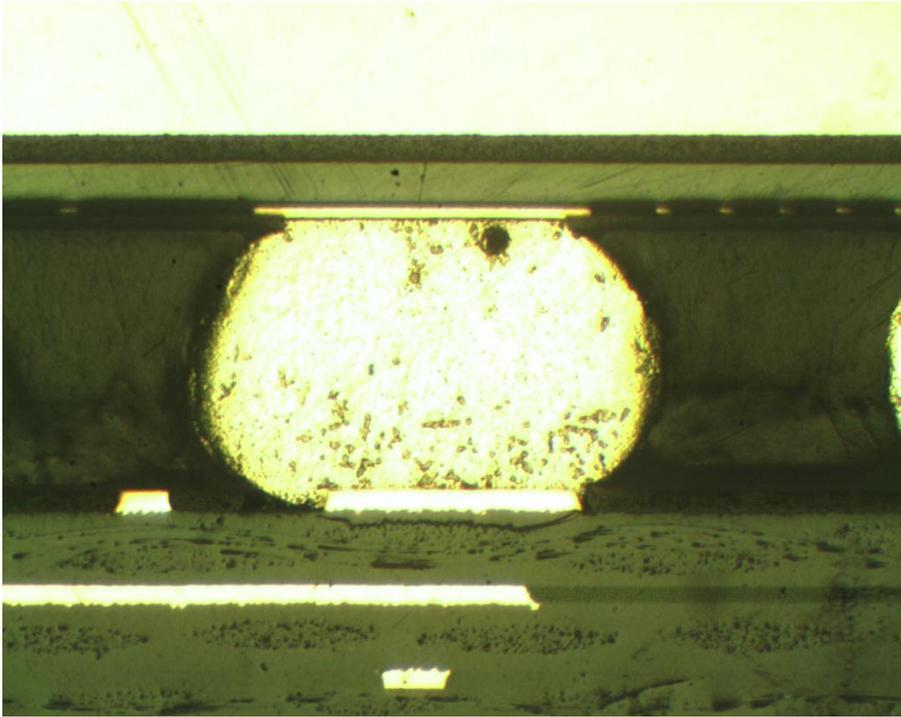


- This occurs when the resin crack (fracture) migrates through a copper trace or via.
- This happens at assembly, in service or during handling.
- When component is removed, PCB copper pad comes with it, leaving behind a “crater” in the PCB.
- Has become more prevalent with lead free assemblies.
- Contributing factors include board thickness, size, resin type, CTE of the PCB and component, solder type, component position, assembly conditions post assembly handling.

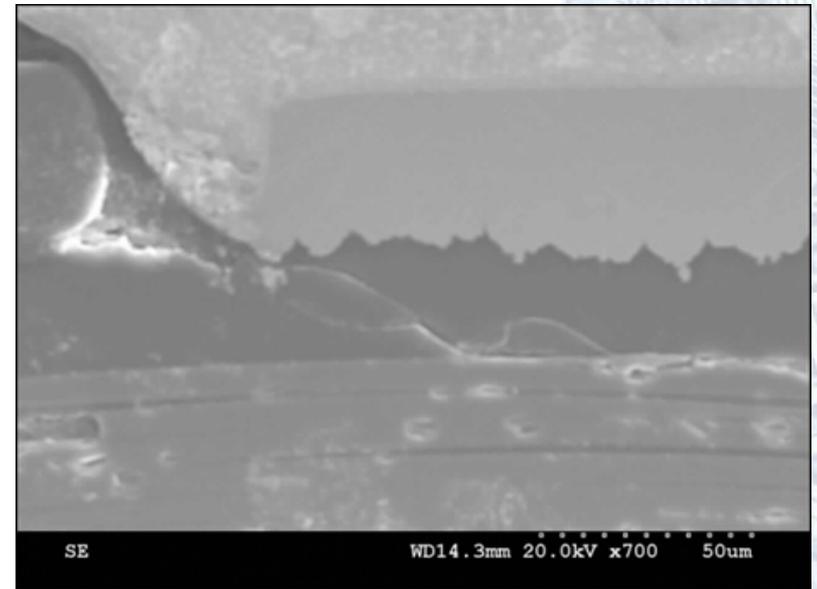
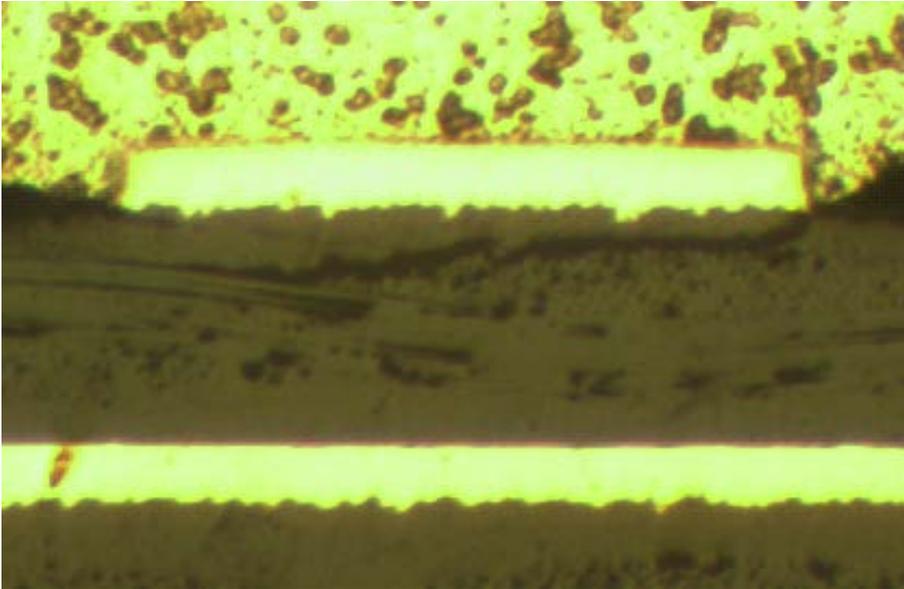
Open in BGA



Pad Craters



Examples of Fractures



Pad Strength Failure Modes

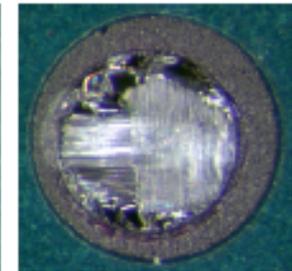
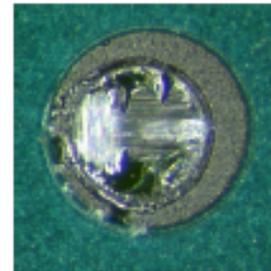
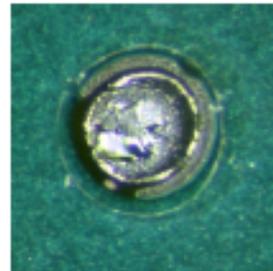
12-mil

18-mil

24-mil

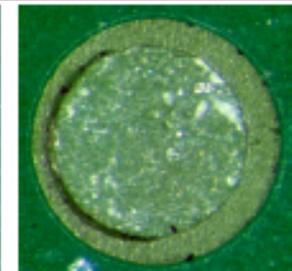
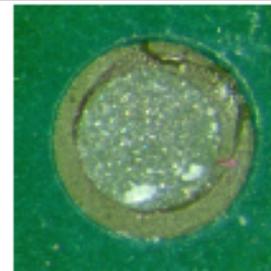
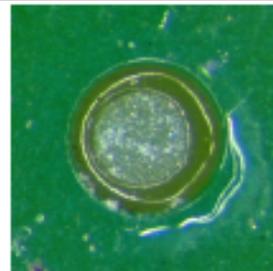
DICY

- Typical unfilled failure mode
- Exposed Glass



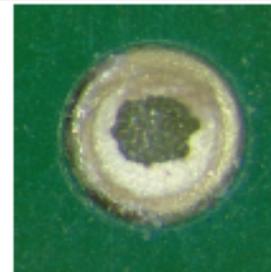
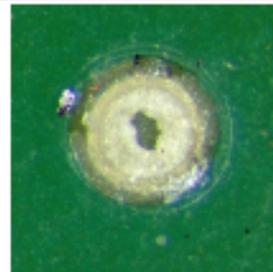
Filled Phenolic

- Typical filled failure mode
- Glass not exposed
- Crater is shallow



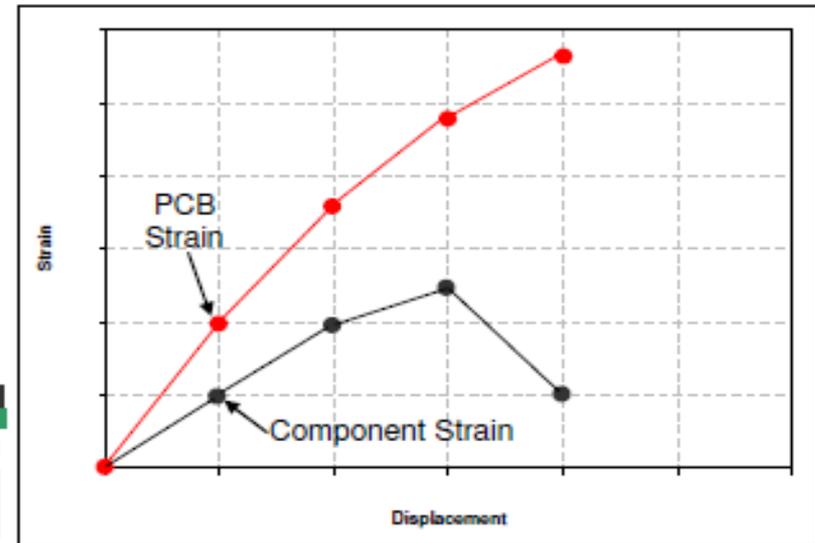
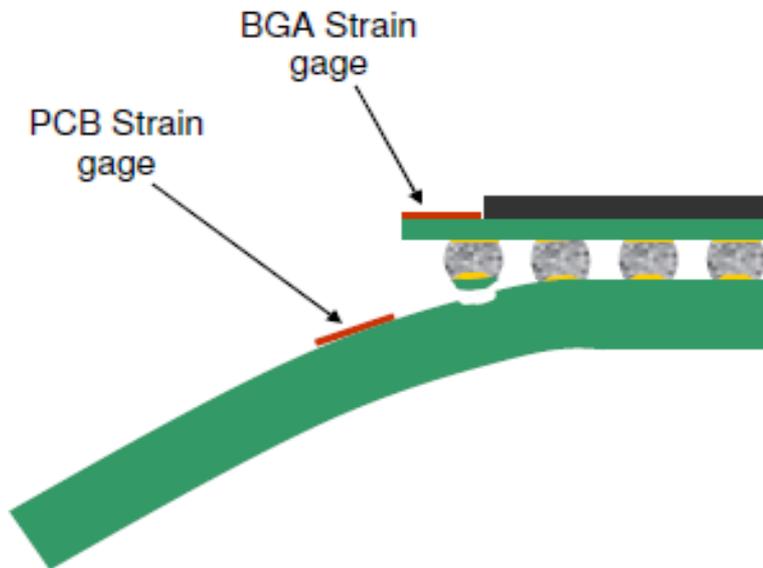
Zeta Cap

- Zeta material breaks away
- Failure between Zeta and FP
- Limited cratering in FP



Inflection Strain Approach

- Measure both PCB and Component bending strain at the same time



How is the Electronics Industry dealing with this Defect Mode?

- Epoxy filets (mounds) at the corner of the BGAs,
- Increased pad or trace widths (Increase in pitch).
- Change trace path.
- Increased board thicknesses.

These fixes are counter to the need to increase board density.

What does this have in common with a Pad Cratering solution?

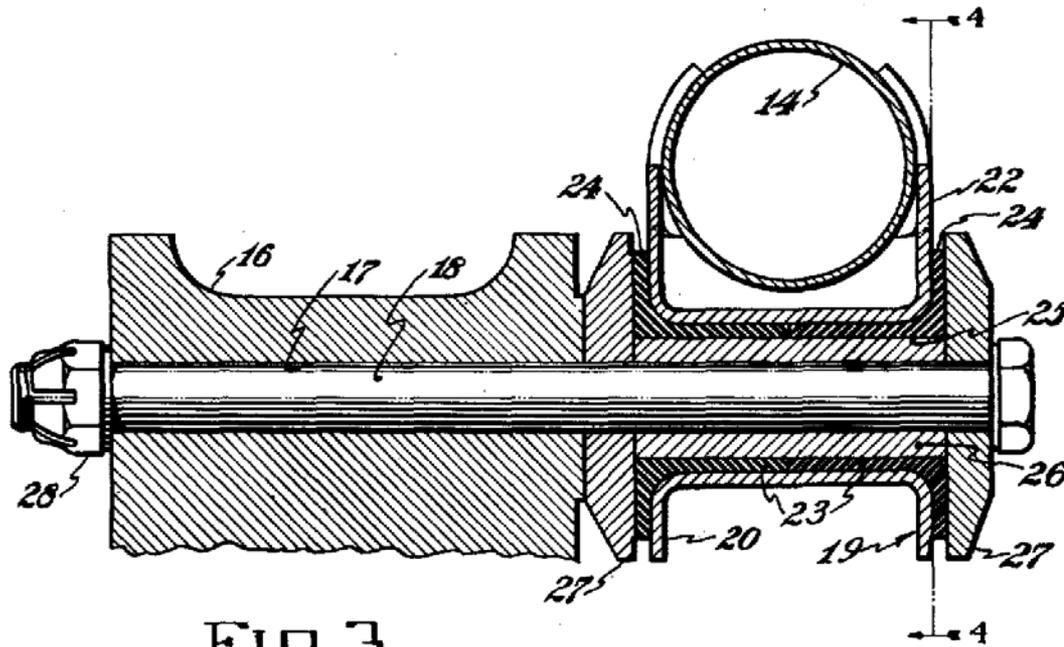


Fig. 3.

- Filed April 12, 1934 US Patent 2,109,329
- Aircraft engine mount with resilient (rubber) layer.
- Prevents fractures in frame from shock and vibration created by engine.

- **re·sil·ient**

- \ri-'zil-yənt\

- *adjective*

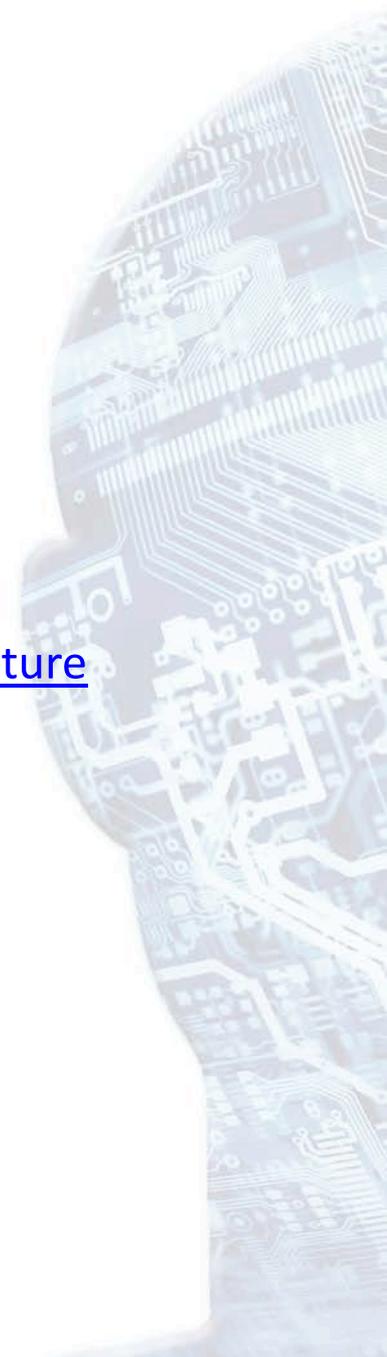
: characterized or marked by resilience: as

a : capable of withstanding shock without permanent deformation or rupture

b : tending to recover from or adjust easily to misfortune or change

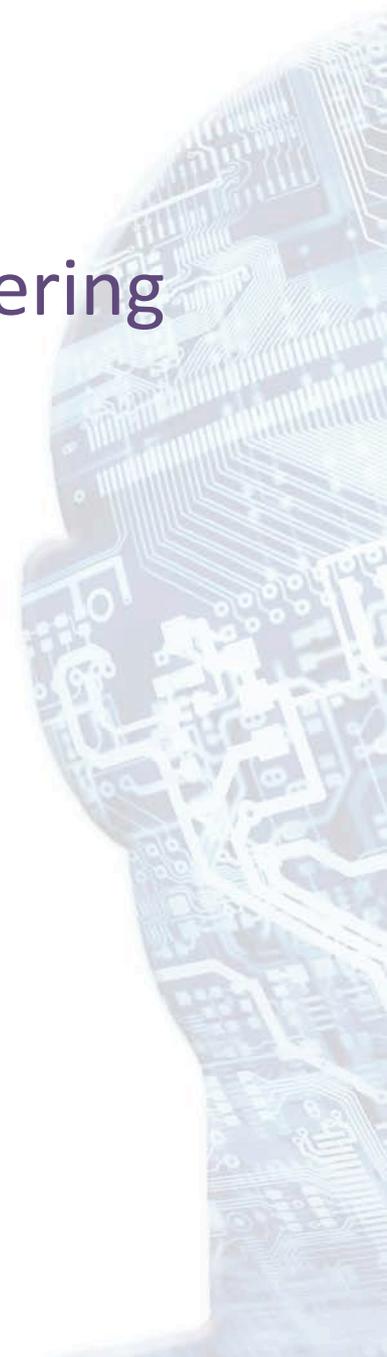
- **synonyms** see elastic

From Merriam-Webster



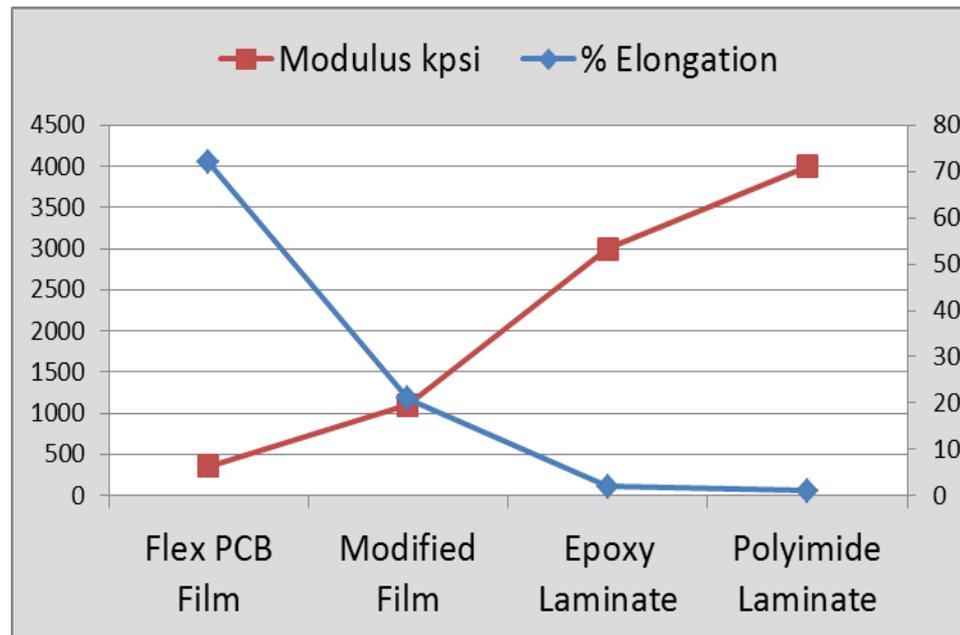
Material Properties that help resist Cratering

- Non-Brittle
- Medium Modulus
- High Tg
- CTE close to copper
- Must also be
 - Lead free solder compatible
 - Halogen free
 - Compatible with normal PCB processing

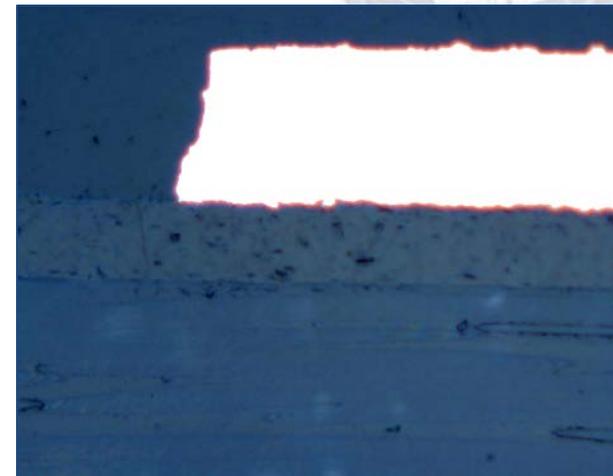
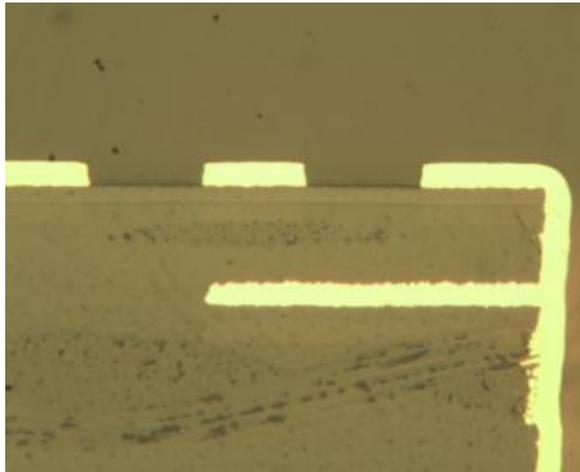
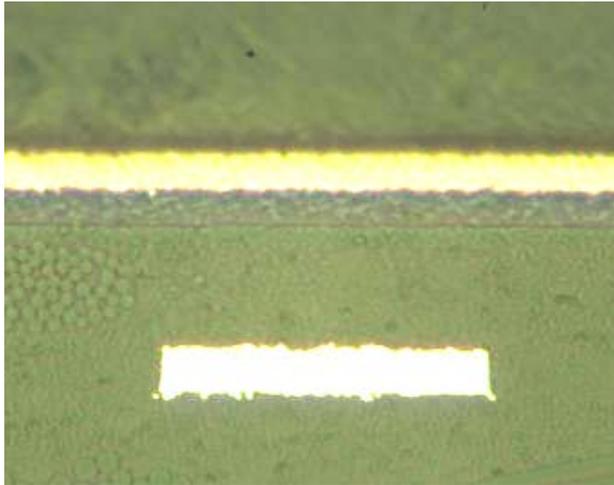


Material developments that are addressing Pad Cratering

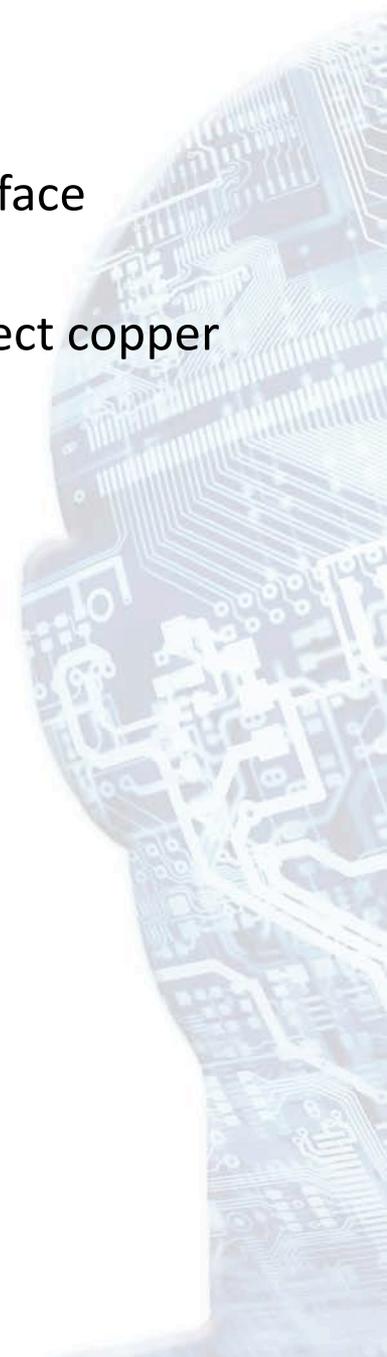
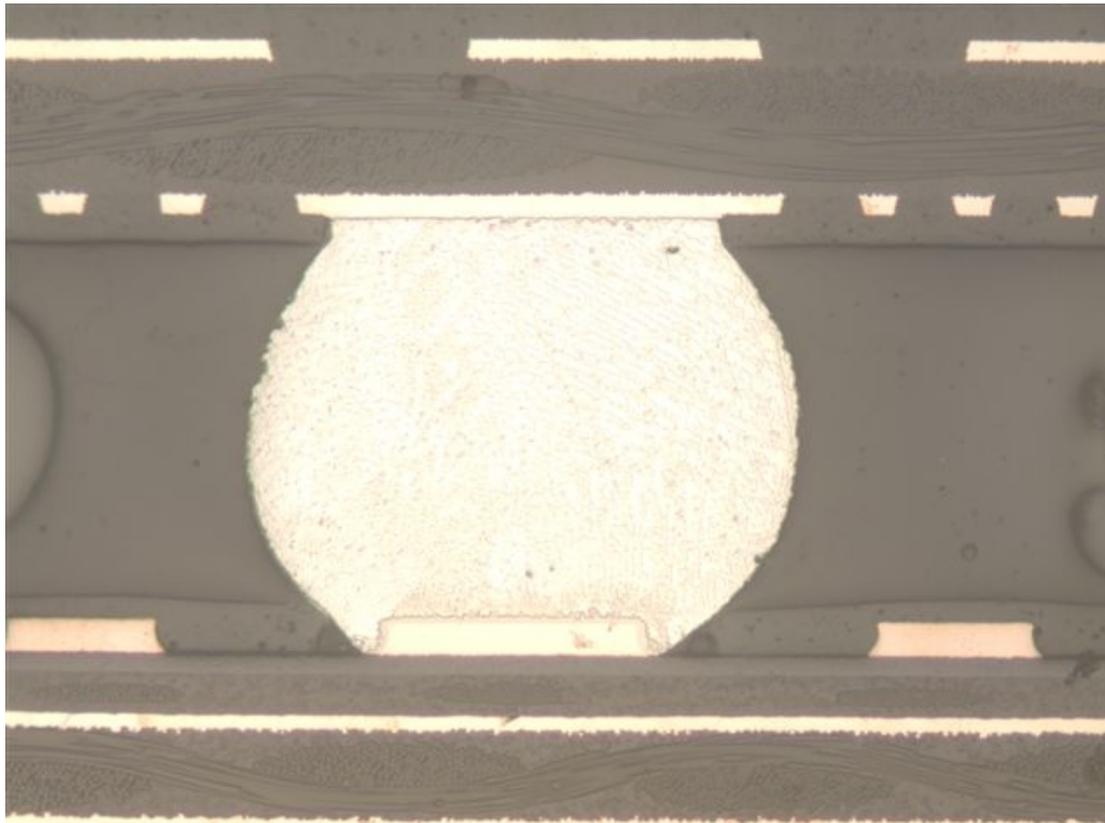
Higher modulus than flex material, yet more flexible than standard rigid materials (see below).



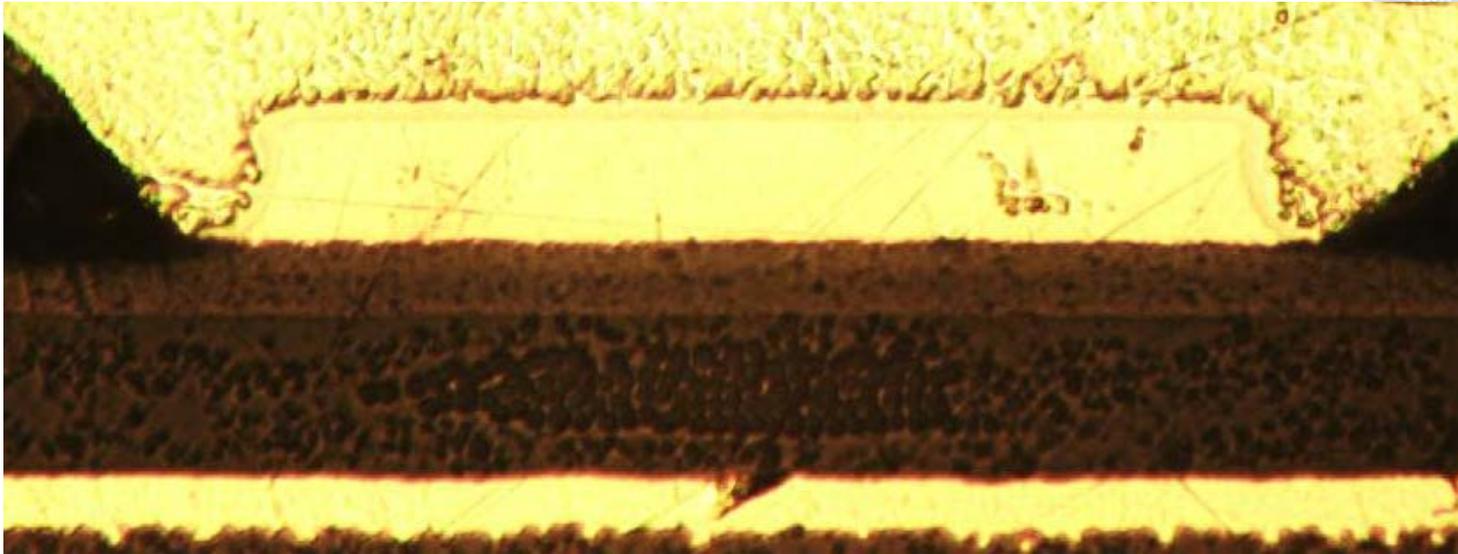
A pad crater resistant structure may be built using a fracture-resistant film on the surface layer. This resilient layer is in direct contact with the copper pad, preventing fractures from starting or reaching the copper trace or via.



- When used as a cap layer (see below) it becomes the interface between the copper pad and the rest of the PCB.
- The more pliant cap will prevent or block fractures and protect copper connections (traces) to the pad.



Fracture Barrier



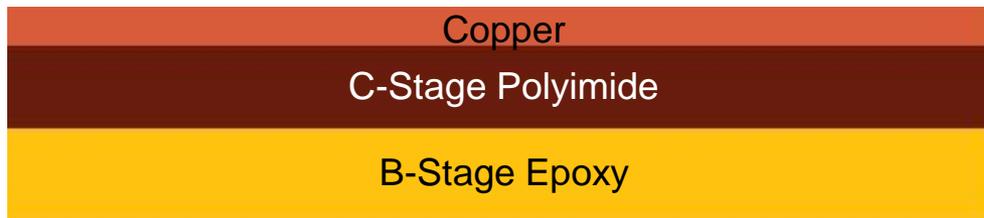
*Courtesy: Murrietta Circuits, Inc.
Anaheim, CA*

Recent papers

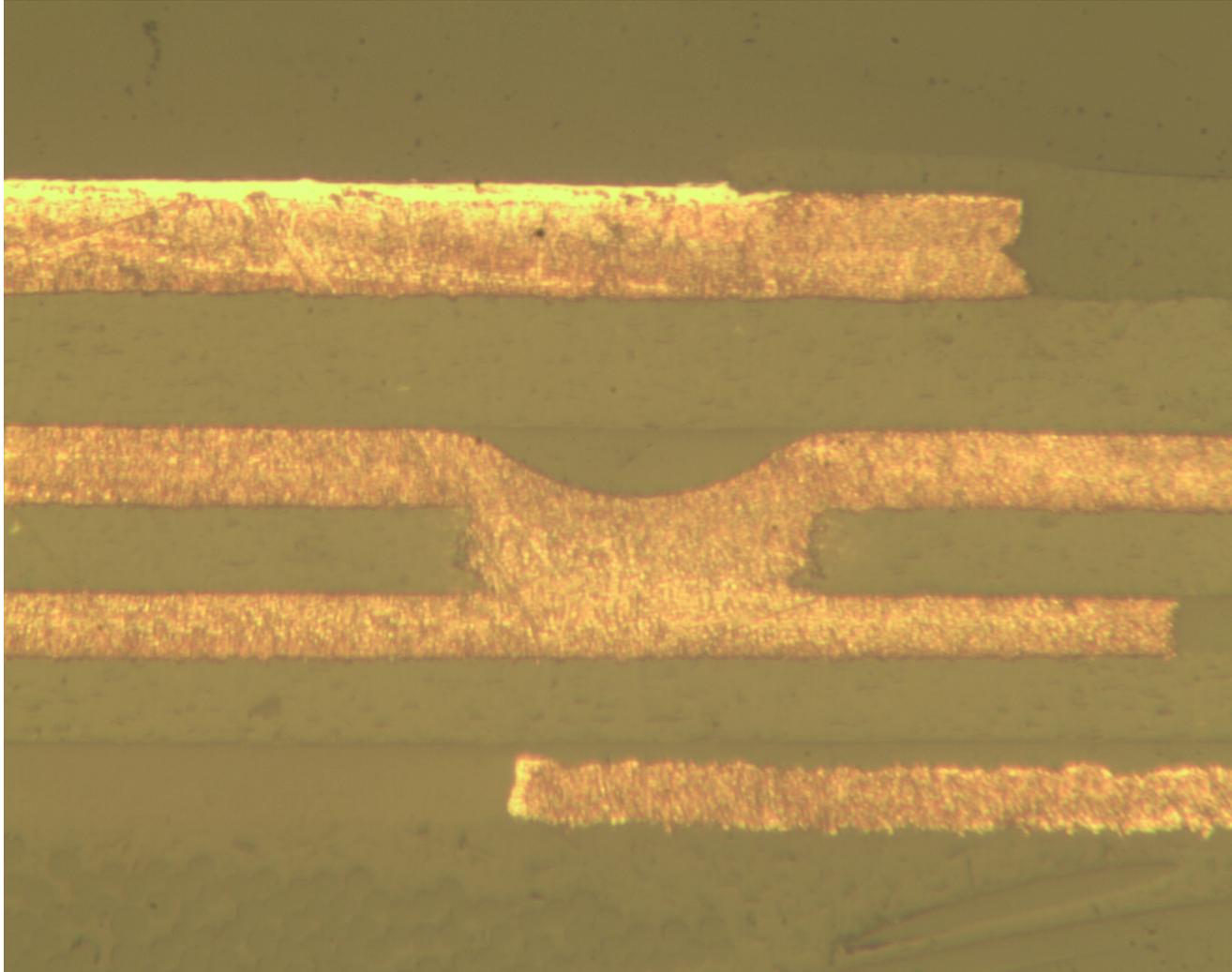
- IPC – Apex, March 2012
 - ***The Application of Spherical Bend Testing to Predict Safe Working Manufacturing Process Strains***
 - John McMahon P.Eng, Brian Gray P.Eng,
 - Celestica, Toronto, Ontario, Canada
 - ***Investigation of Pad Cratering in Large Flip-Chip BGA using Acoustic Emission***
 - Anurag Bansal, Cherif Guirguis and Kuo-Chuan Liu
 - Cisco Systems, Inc., San Jose, CA
- Area Consortium, March 2012
 - ***PCB Evaluations, Mechanical Testing***
 - Michael Meilunas
 - Universal Instruments, Conklin, NY

ZETA[®] LAM

- **Zeta[®] LAM = Zeta[®] Cap + Zeta[®] Bond SE**
 - Complete HDI material package with copper
 - C-stage layer provides a polymer solution to fiberglass;
 - Consistent thickness control after lamination
 - Very high dielectric strength
 - Lower Z-axis CTE than other glass free dielectrics materials
 - Lower Dk, Lower loss, less transmission line variation (no glass bundles)
 - High copper peels at high temperatures
 - B-stage layer provides;
 - Bonding and fill of circuits and vias
 - Various thicknesses of resins are available for fill requirements
 - Curable with standard PCB laminating equipment @190°C (375°F)
 - Non brittle with a long shelf life, 1 year at room temperature



Zeta[®] Lam

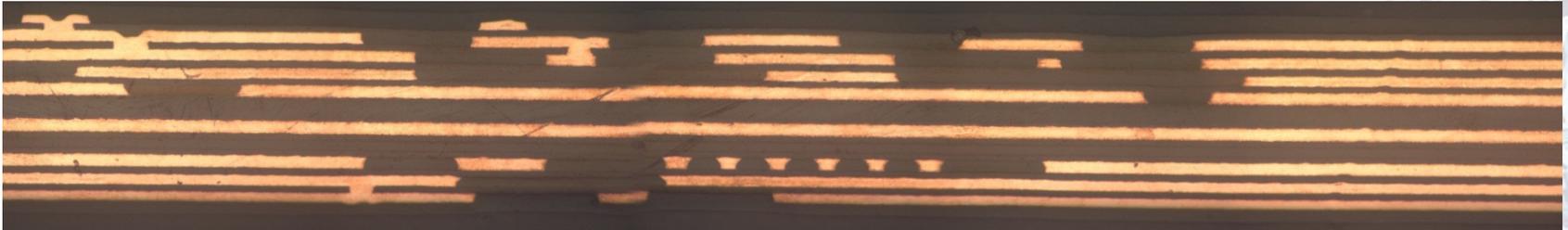


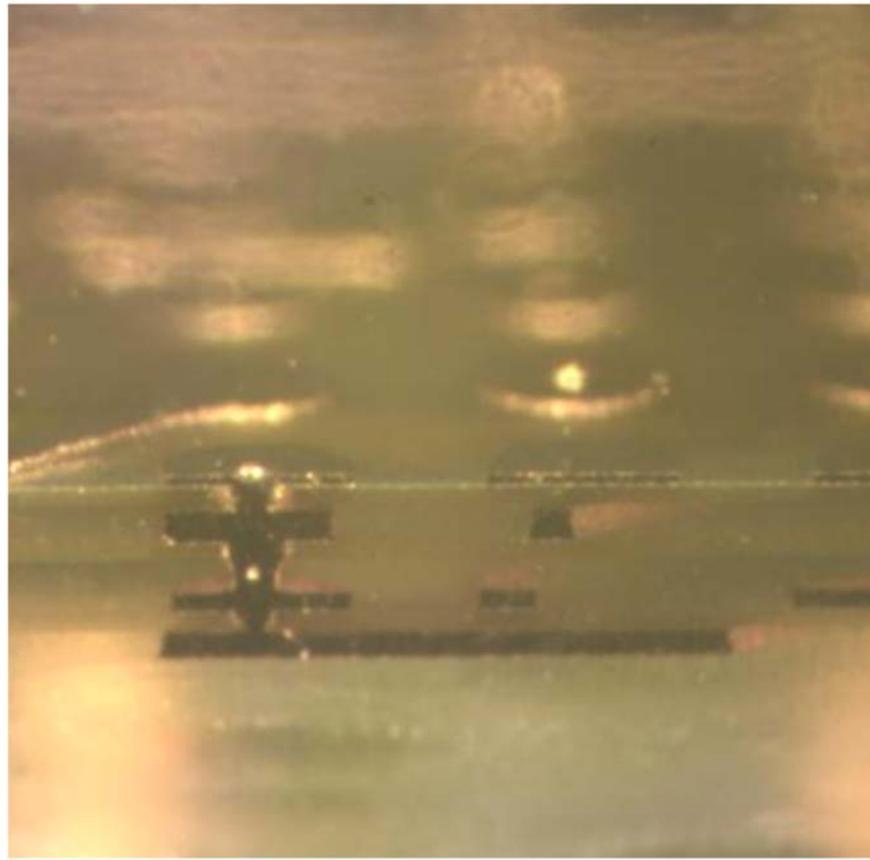
Zeta[®] Lam

8 layers of ZETA[®] LAM in 10 layer PCB

Total thickness – 16 mils

Combined dielectric thickness 6 mils copper to copper





QUESTIONS?