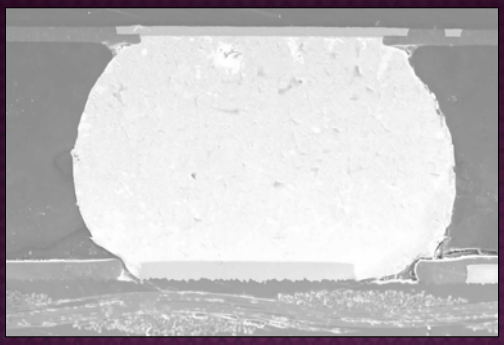
IEEE
Santa Clara
Valley Chapter
10/10/2012

Pad Cratering
On
PCB's



INTEGRAL TECHNOLOGY

- 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."

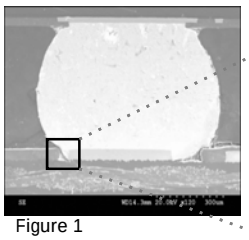


Figure 1

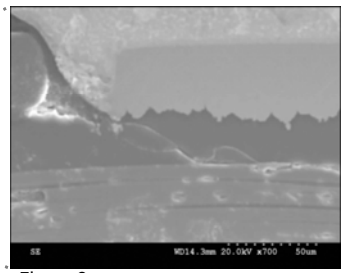
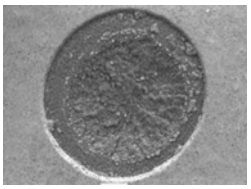


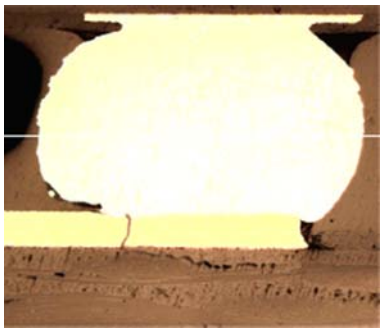
Figure 2

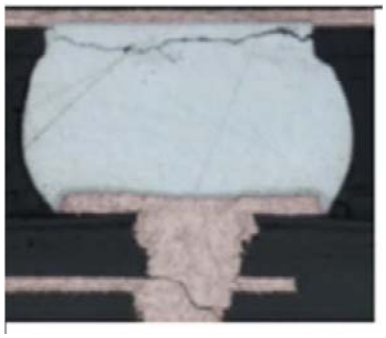
PAD CRATERING… OPENS CIRCUITS



- 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.

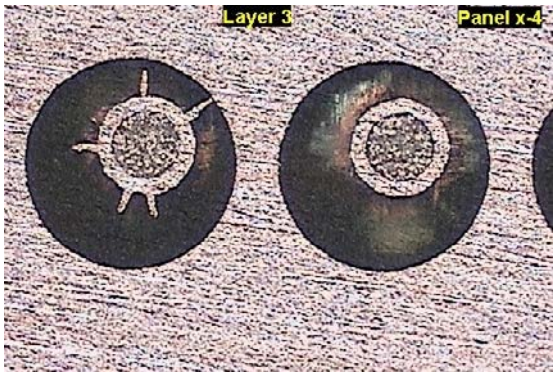
PAD CRATERING and VIA FRACTURES





4

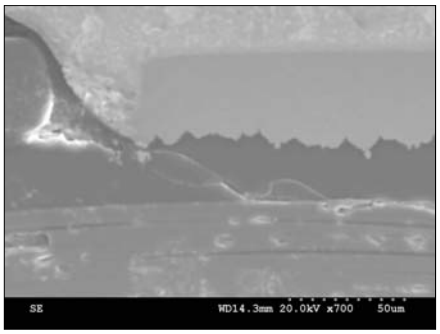
INTERNAL FRACTURES

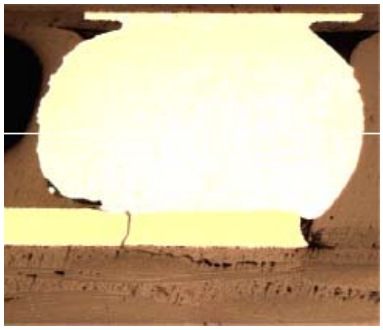


5

PAD CRATERING

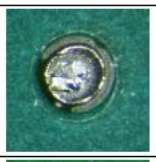
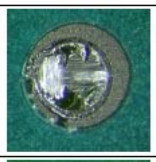
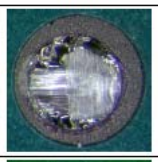
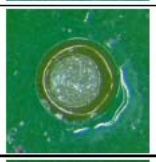
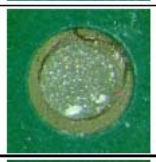
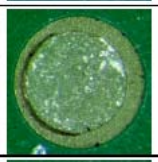
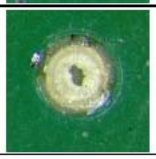
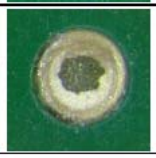
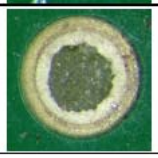
- Mechanical in nature, but may be thermally induced.
- Popular lead free solder compatible materials tend to be more brittle.





6

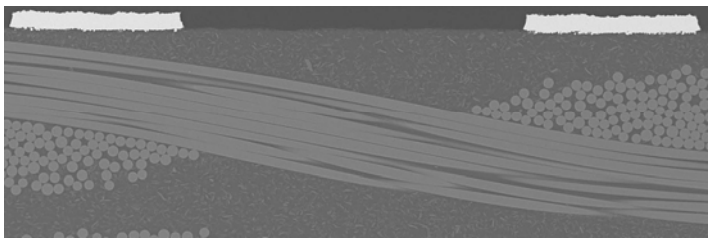
Pad Strength Failure Modes

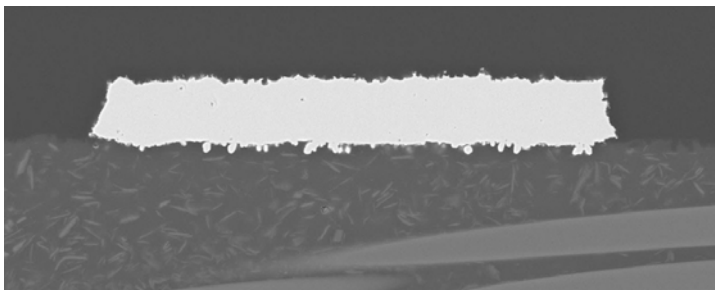
	12-mil	18-mil	24-mil
DICY • Typical unfilled failure mode • Exposed Glass			
Filled Phenolic • Typical filled failure mode • Glass not exposed • Crater is shallow			
Zeta Cap • Zeta material breaks away • Failure between Zeta and FP • Limited cratering in FP			

Courtesy: Universal Instruments, Conklin, NY

16 June 15, 2011 Pad Cratering: Evaluation of Zeta Cap Roggeman@uic.com

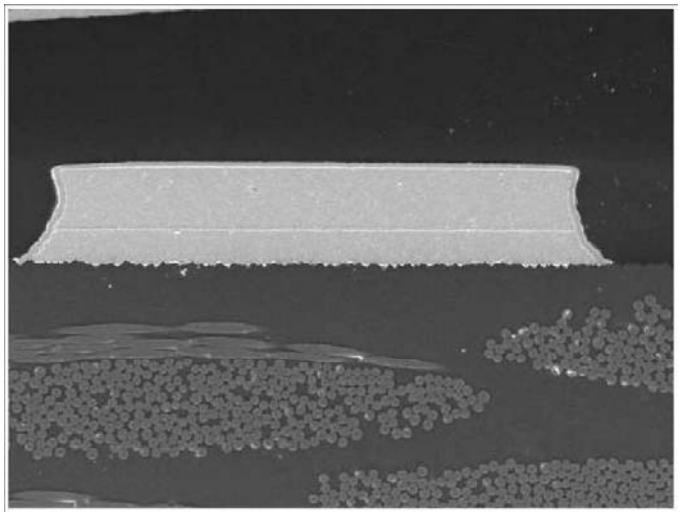
FILLED RESIN SYSTEM





8

UNFILLED



9

WHY NOW?

- Pad Cratering is not new.
- Lead Free assembly.
  - Different alloy of solder (SAC)
    - Higher assembly temperatures.
    - Different mechanical properties in solder joint.
  - Different PCB materials
    - Needed for higher assembly temperatures.
    - Epoxy/Phenolic systems are popular.
      - Cure temperature
      - Decomposition temperature sufficiently high
      - Cost
      - Shelf life

    These systems do much better in regards to delamination, but they tend to be more brittle.

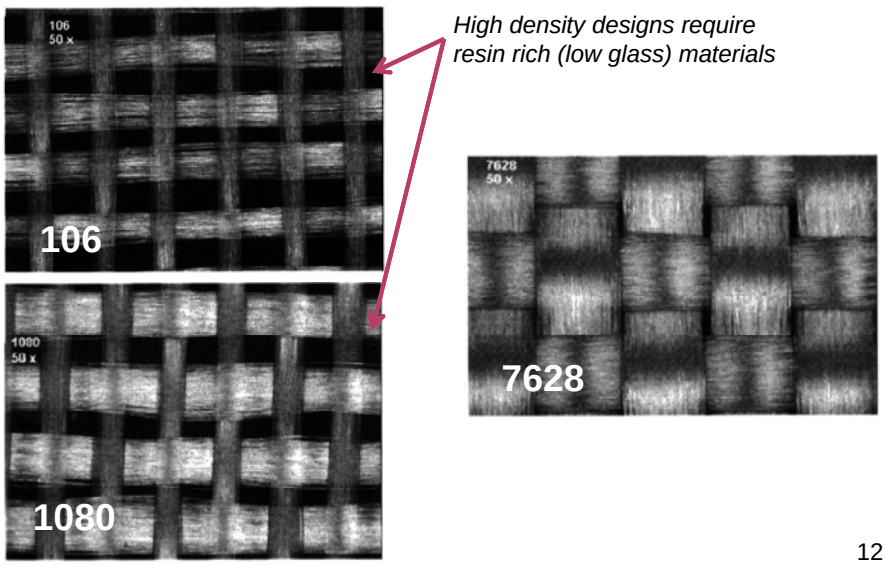
10

CTE

- IPC TM-650 2.4.24
  - Glass Transition Temperature and Coefficient of Thermal Expansion (CTE)
    - Thickness of test sample – 0.4 to 29.5 mils
  - Epoxy/phenolics (popular choice for lead free solder)
    - Data sheet – x, y CTE – 10 to 15 ppm
    - Measured single ply 1080 – 30 to 35 ppm
    - Glass styles as well as glass to resin ratio impact CTE in all three dimensions.

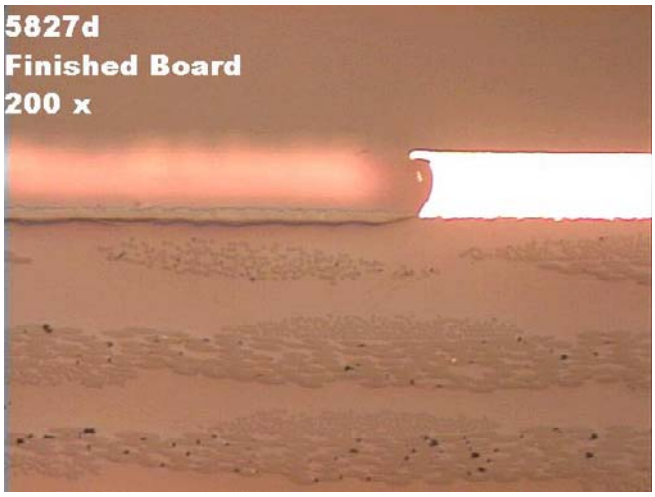
11

GLASS FABRIC



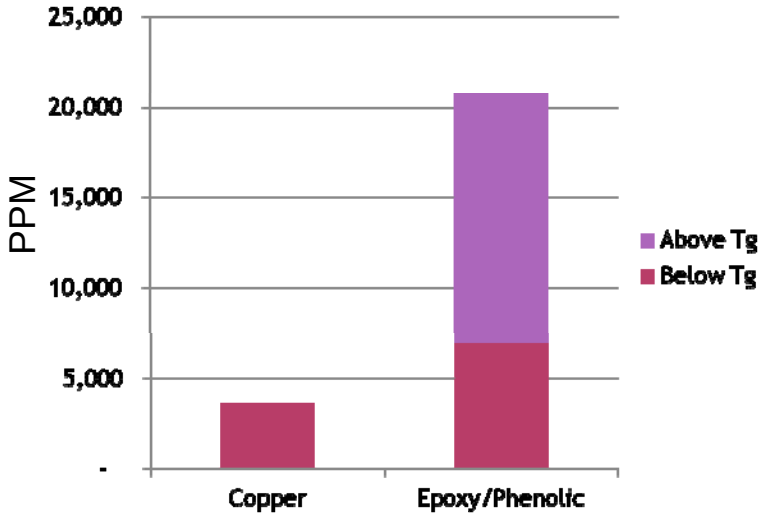
12

HIGH RESIN PREPREGS TYPICALLY USED ON SURFACE LAYER



13

THERMAL EXPANSION FROM ROOM TEMP TO 240° C (Tg - 180°)

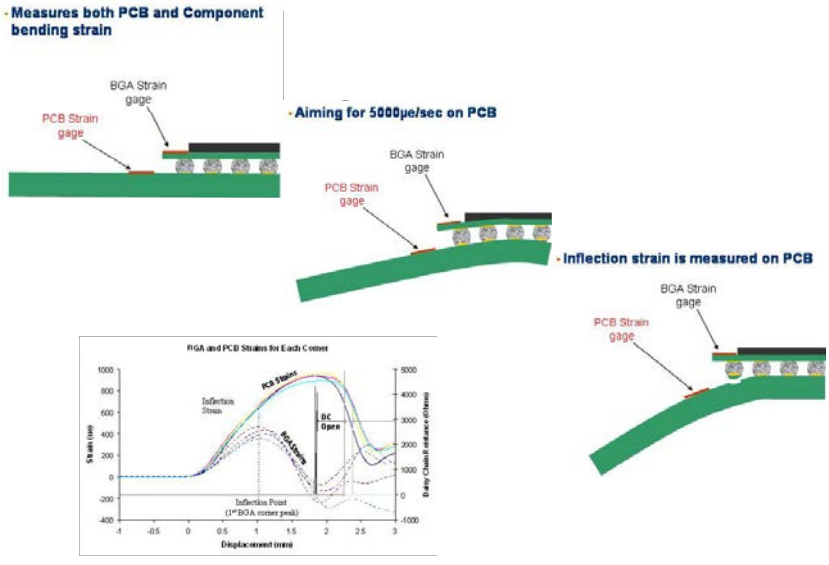


MISMATCH IN CTE BUILDS ADDITIONAL STRESS

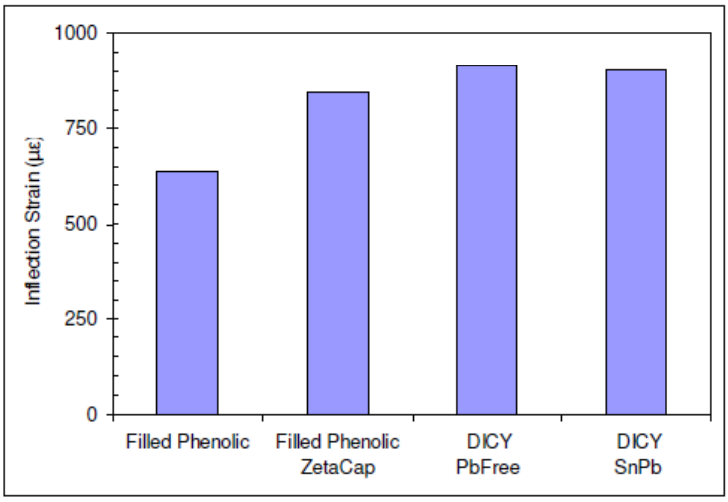
- During heat up and reflow, the PCB and BGA expand different amounts.
- During cool down, PCB and BGA return to normal size, but the lead free solder freezes at 220 ºC
- After the solder freezes, PCB still wants to contract, locking in stress.
- Tin Lead - 183ºC (peak 210 to 225º C)
- SAC (lead Free) 217º (peak temp 235 to 255º C)

15

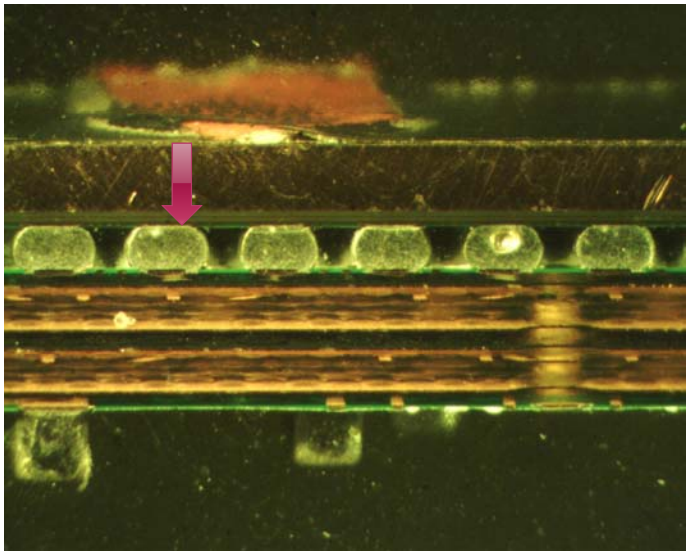
SPHERICAL BEND TEST - INFLECTION STRAIN IPC/JEDEC-9707



INFLECTION STRAIN RESULTS OF SOME PCB MATERIALS

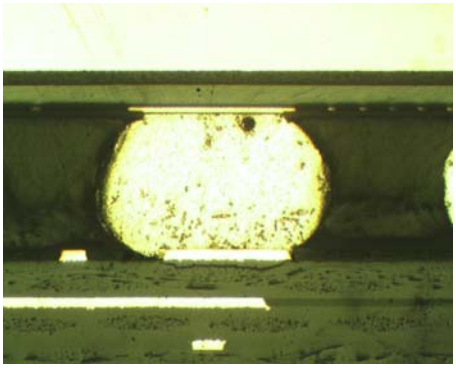


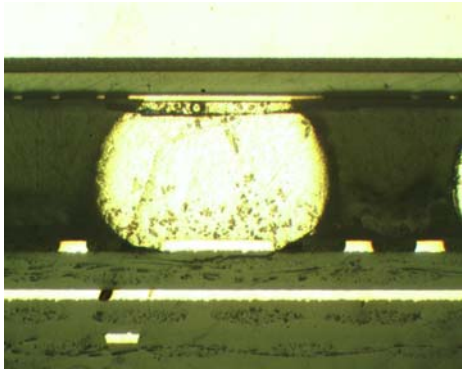
OPEN IN BGA



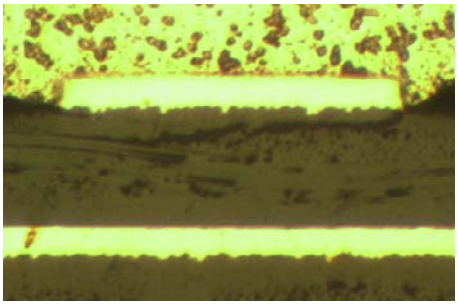
18

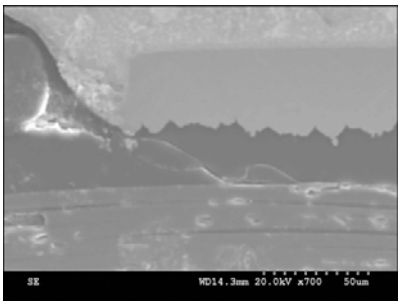
PAD CRATERS





EXAMPLES OF FRACTURES





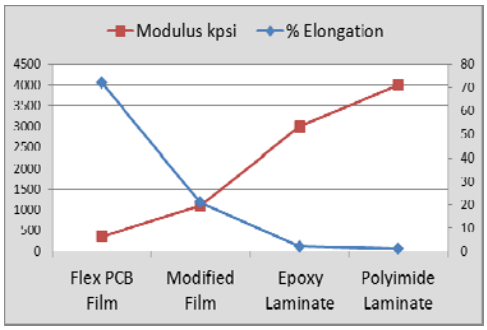
HOW IS THE ELECTRONICS INDUSTRY DEALING WITH THIS DEFECT MODE?

- Underfill
  - Testing shows this can move the fracture from the solder ball to the PCB.
- Epoxy filets (mounds) at the corner of the BGAs.
  - Fracture are more common at the corners of the BGA.
- Increased pad or trace widths (Increase in pitch).
- Change trace path.
- Increased board thicknesses.

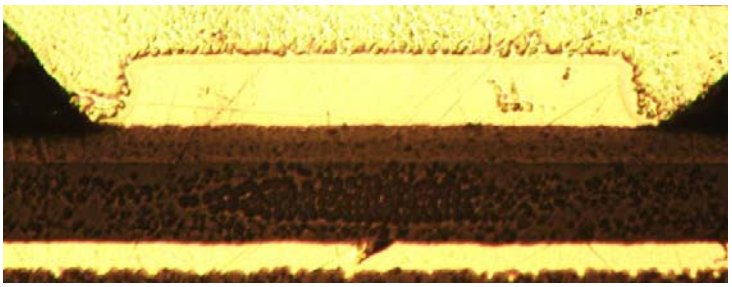
These fixes are counter to the need to increase board density.

MATERIAL DEVELOPMENTS THAT ARE ADDRESSING PAD CRATERING

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



FRACTURE BARRIER



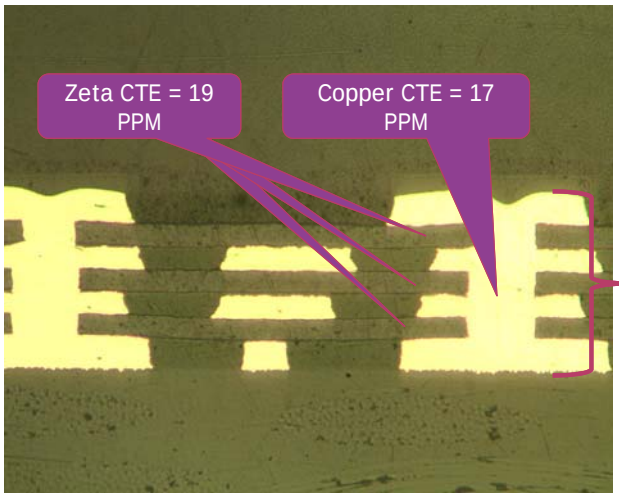
Courtesy: Murrietta Circuits, Inc.
Anaheim, CA

PAPERS ON PAD CRATERING

- 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

24

ZETA® FOR STACKED VIAS



4 layers of copper circuits in 200 microns

Total of 75 microns of dielectric

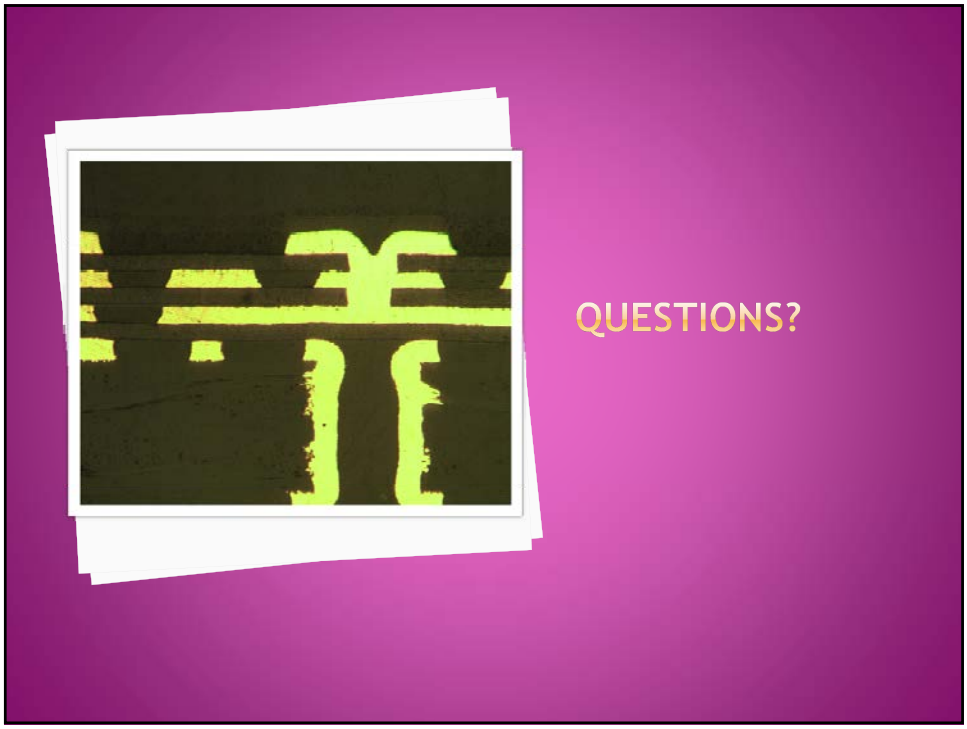
25

8 LAYERS OF ZETA® LAM IN 10 LAYER PCB

TOTAL THICKNESS - 16 MILS

COMBINED DIELECTRIC THICKNESS 6 MILS COPPER TO COPPER
12 MICRON DIELECTRICS

26


QUESTIONS?