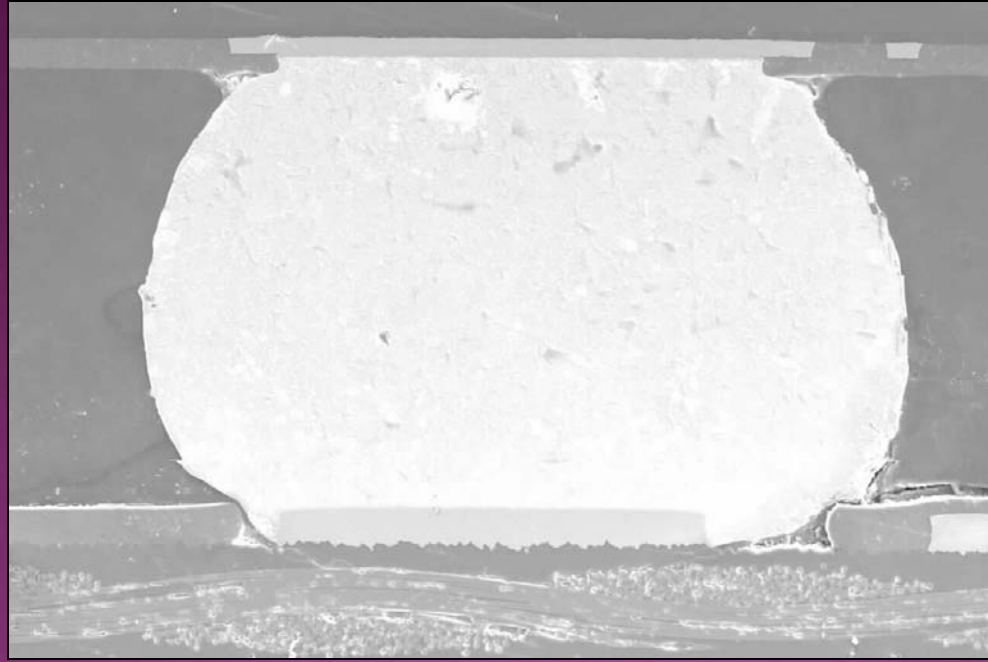


Zeta® For  
Printed Circuit  
Boards



# INTEGRAL'S FAMILY

**L.C.O.A.**<sup>®</sup>  
LAMINATING COMPANY OF AMERICA

**INSULECTRO**  


 **CAC**

**TRI STAR**  
INTERNATIONAL  


Technical Support for the family of businesses

- Technical Services
- Research & Development
- Field Installations
- Process Development
- Process Audits
- Defect Analysis

 **INTEGRAL TECHNOLOGY**

*Vistana*  


**L.C.O.A.**  
COMPOSITES  


 **Redfern Partners**

NEXT GENERATION HDI

# WHAT IS ZETA<sup>®</sup>?

- Zeta<sup>®</sup> is a new family of PCB materials.
- Zeta<sup>®</sup> materials are based on high performance polymers in FILM form.
- Zeta<sup>®</sup> materials do not contain fiberglass.
- Zeta<sup>®</sup> materials are provided as C stage or B stage films combined with copper foil.
- Zeta<sup>®</sup> provides PCB fabricators an alternative to RCC and liquid dielectrics.

# Zeta Applications

## Lead Free - OEMs

- Pad Cratering
- Surface Copper Peel Strength
- CAF resistant
- High Tg and Td, Low CTE
- Halogen Free

## HDI – PCB shops+ OEMs

- Thickness reduction
- Low Dk and Df
- Via Formation
- Plating
- Multiple Lam Cycles (>10)

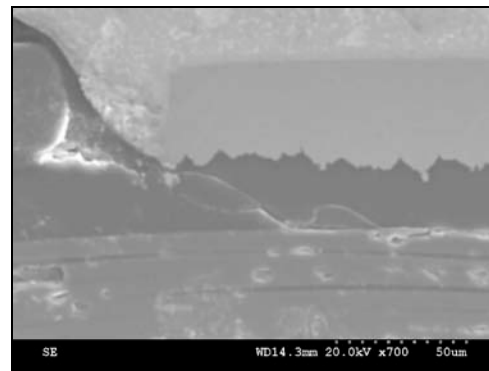
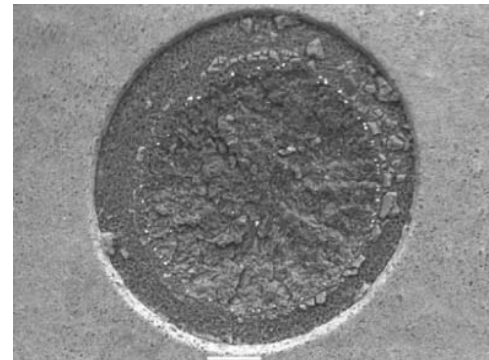
# Zeta Lead Free Assembly Applications

## Lead Free - OEMs

- Pad Cratering
- Surface Copper Peel Strength
- CAF resistant
- High Tg and Td, Low CTE
- Halogen Free

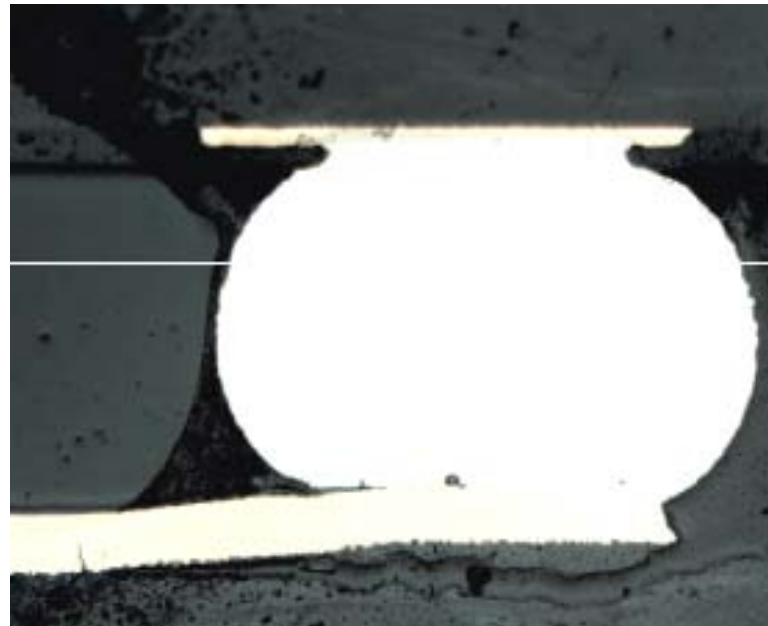
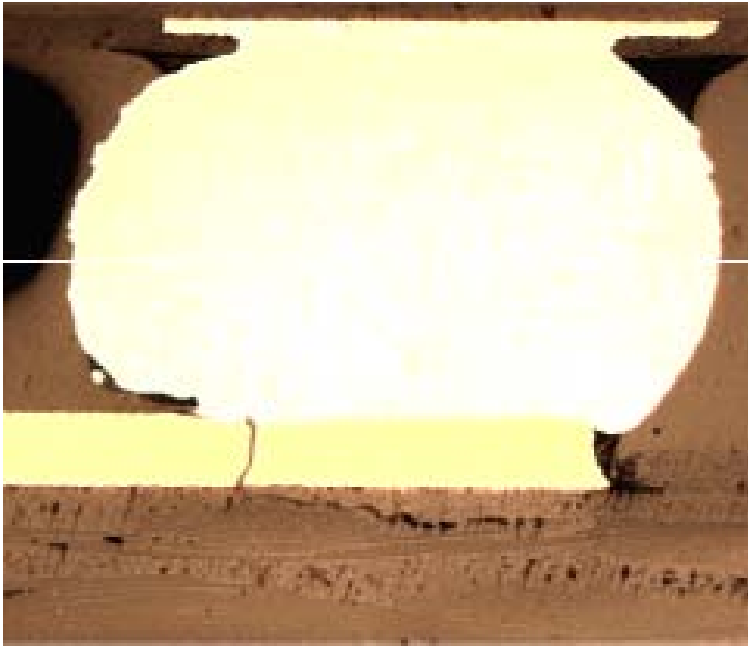
# PAD “CRATERING”

- Mechanically induced fracture in the resin between copper foil and outermost layer of fiberglass. May be within the resin or at the resin to glass interface.
- Pad remains connected to the component (usually BGA) and leaves a “Crater” in the PCB.



# PAD “CRATERING” = Opens

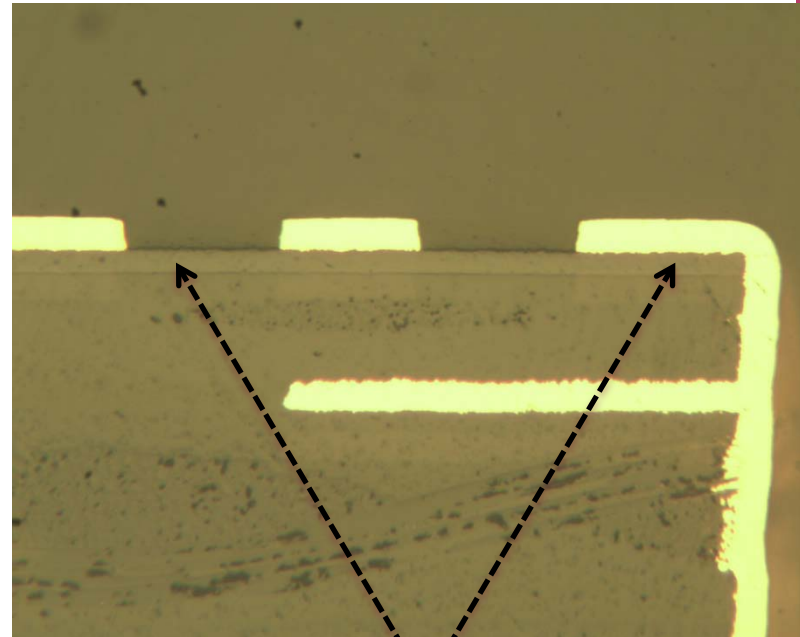
- Fractures start in the dielectric (resin) and work through the copper trace creating an open circuit.



# ZETA<sup>®</sup> Cap for Pad Cratering

“Drop in” to existing designs

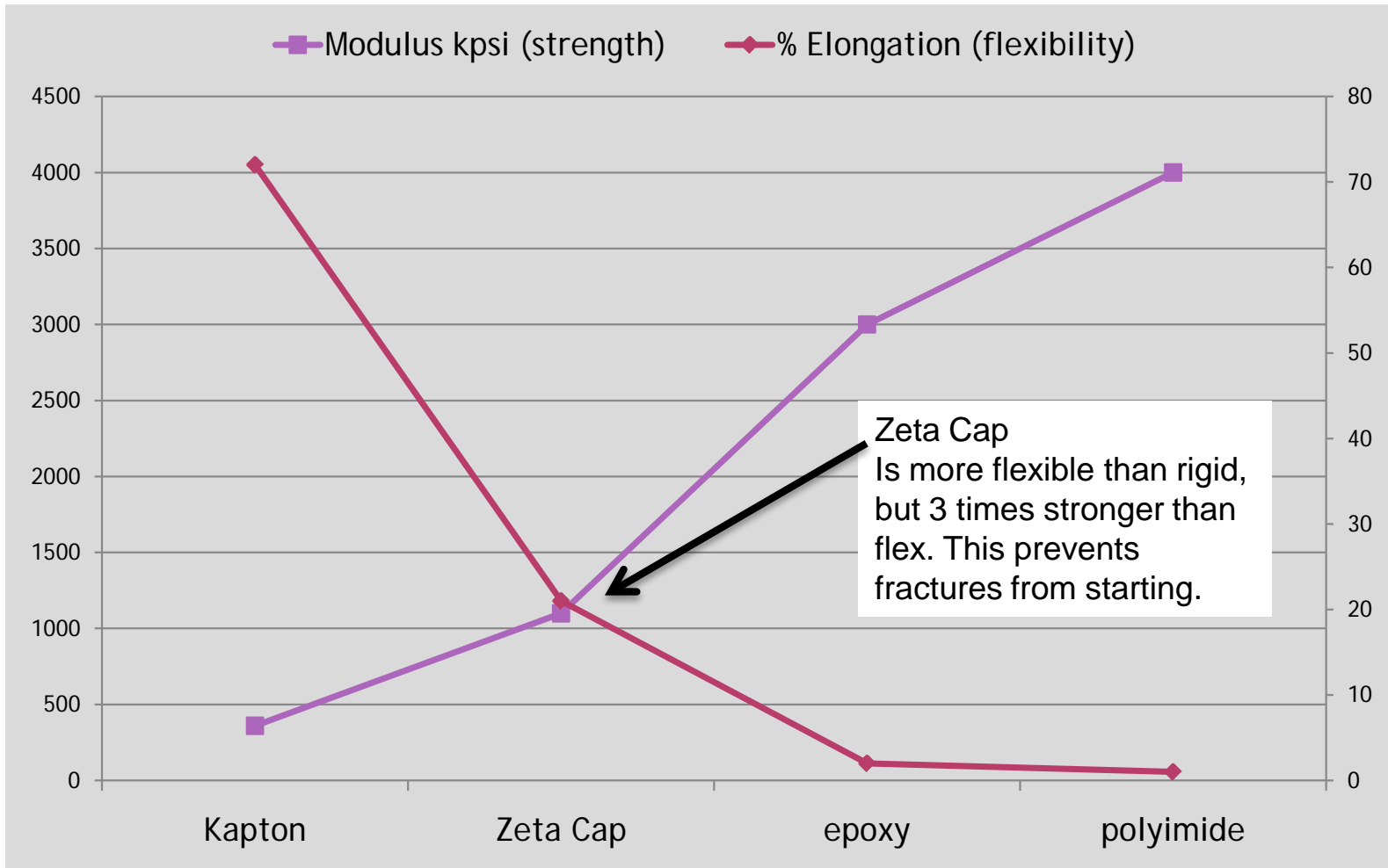
- Unique material properties, Zeta<sup>®</sup> acts as a crack stop.
- Pad Crater solution without changing base materials.
- Reduces need for under-fill.
- Resistant to field handling, installation and service issues.
- Improves Drop test performance.
  - Hand held devices
- Greater component rework success.



Zeta<sup>®</sup> Cap



# ZETA<sup>®</sup> CAP MECHANICAL PROPERTIES



# ZETA<sup>®</sup> CAP DETAILS

## ◎ Copper

- ¼ oz (9 µm), 3/8 oz (12 µm), ½ oz (18 µm)
- Low tooth profile
- 6 to 7 pound peel strength
- RTF finish

## ◎ C stage Dielectric

- 0.5 mil (12 µm), 1.0 mil (25 µm), 1.5 mil (38 µm)
- Non-copper side treated for prepreg bonding
- $T_g > 300^{\circ}\text{C}$ ,  $T_d > 500^{\circ}\text{C}$
- @ 2GHz -  $D_k = 3.0$ ,  $D_f = .005$
- Dielectric Strength - 4900 v/mil
- Halogen Free

# ZETA<sup>®</sup> CAP STATUS

- UL

- 94-V0, MOT 155°C

- Pad Crater Testing

- 1.0 mil with Pad Crater TV, hot pin pull test with OEM #1
- Prototype boards built with 0.5 and 1.0 mil with OEM #1
- Pad Crater TV PCBs under construction for OEM #2
- Pad Crater TV design completed for OEM #3, PCB construction to follow.

# LEAD FREE ASSEMBLY SUMMARY

- ◉ Questions regarding Zeta<sup>®</sup> lead free assembly applications?

# Zeta HDI Applications

## HDI – PCB shops+ OEMs

- Thickness reduction
- Low Dk and Df
- Via Formation
- Plating
- Multiple Lam Cycles (>10)

# ZETA<sup>®</sup> C STAGE/ B STAGE PRODUCTS

## ○ Zeta<sup>®</sup> Cap

- Copper clad high Tg, low CTE fully cured dielectric.
- Used with standard prepregs or Zeta<sup>®</sup> Bond.



## ○ Zeta<sup>®</sup> Bond

- Hi Tg "B" stage film that is glass free.
- Thickness is easily tailored to fill areas around plated circuits.
- Hi peels, even after multiple lam cycles.



## ○ Zeta<sup>®</sup> Lam

- Zeta<sup>®</sup> Cap + Zeta<sup>®</sup> Bond
- Ready to use in Lay-up without Prepreg



# ZETA<sup>®</sup> BOND SE

- New epoxy technology for multiple lam cycles
  - Non-dicy
  - Non-phenolic
- Room temp storage
- High Tg and High Td
- High flow and fill
- Low moisture absorbing
  - Tg after 72 hours in boiling water- 174°C
  - Moisture uptake @ 72 hours in boiling water – 1.0%
  - Moisture uptake for Kapton, 24 hrs room temp -2.8%
- Requires change in press cycle
  - Start temp is 350°F instead of 200 - 250°F

# SE RESIN LAMINATION

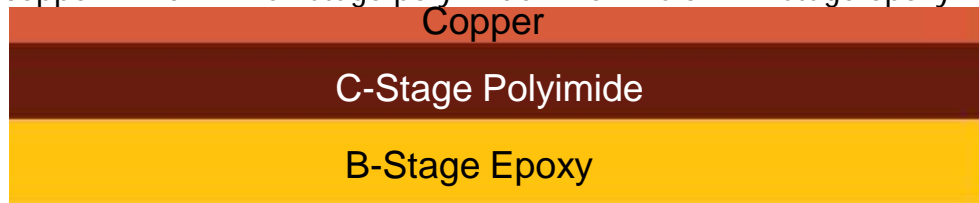
- ⦿ Epoxy based high density crosslinking resin
  - Requires more heat to gel
  - Much longer shelf life - > 1 year
  - Does not require refrigeration
  - Non-brittle B stage
  - Halogen free and not brittle after cure
- ⦿ 350°F to gel in 15 minutes
- ⦿ 375 °F for 90 minutes to cure



# ZETA® LAM

## ○ Zeta® LAM

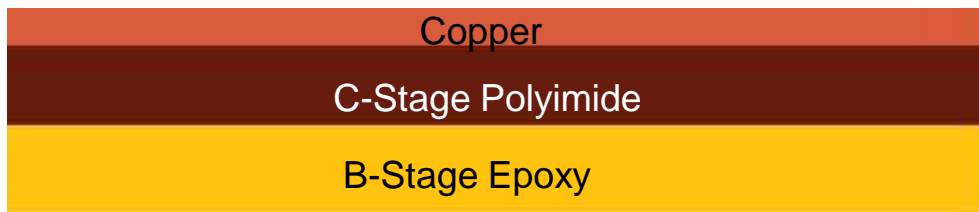
- C-stage layer provides a polymer solution for glass fabric;
  - Consistent thickness control after lamination
  - Very high dielectric strength
  - Lower Z-axis CTE than other glass free dielectrics materials
  - Lower Dk, Lower loss
  - High copper peels at high temperatures
- B-stage layer provides;
  - Bonding and fill of circuits and vias
    - Various thicknesses of resins are available for fill requirements
  - Curable with standard PCB laminating equipment (375°F)
  - Long shelf life, 1 year at room temperature
- IPC-4563
  - Example -  
Zeta Lam C25EP/B38E TSL AA  
=1/3 oz copper + 1.0 mil "C" stage polyimide +1.5 mils of "B" stage epoxy



# ZETA<sup>®</sup> LAM

## ○ Zeta<sup>®</sup> LAM

- Available Coppers
  - ¼ oz (9 micron)
  - 3/8 oz (12 micron)
  - ½ oz (18 micron)
- C-stage layer
  - ½ mil (12 micron)
  - 1 mil (25 micron)
  - 1.5 mil (38 micron)
- B-stage layer
  - 1 mil (25 micron)
  - 1.5 mil (38 micron)
  - 2.0 mil (50 micron)



# HDI CONSTRUCTION TYPES

- ◉ Sequential lamination
  - Starts with double sided core
  - Materials can be
    - Prepreg
    - RCC
    - Photo dielectric (liquid and film)
    - Screenable liquid
- ◉ Parallel lamination
  - Process is used for thru hole multilayers
  - For Any Layer HDI, z-axis interconnects might be;
    - Conductive Ink
    - Copper posts/cones
- ◉ “Subs” (cannot produce “Any Layer”)
  - Combination of sequential and parallel

# HDI CONSTRUCTION TYPES

## ◉ Sequential lamination

- Advantages
  - “Any Layer” HDI capable
  - Uses standard PCB processing
  - Thin structures possible
- Disadvantages
  - Requires multiple laminations

## ◉ Parallel lamination

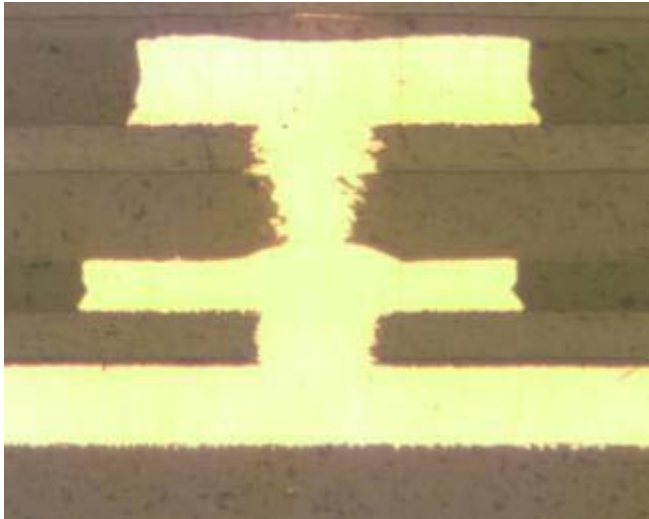
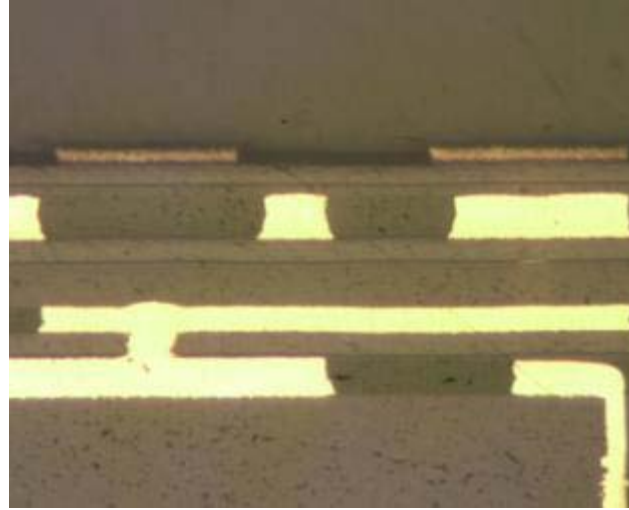
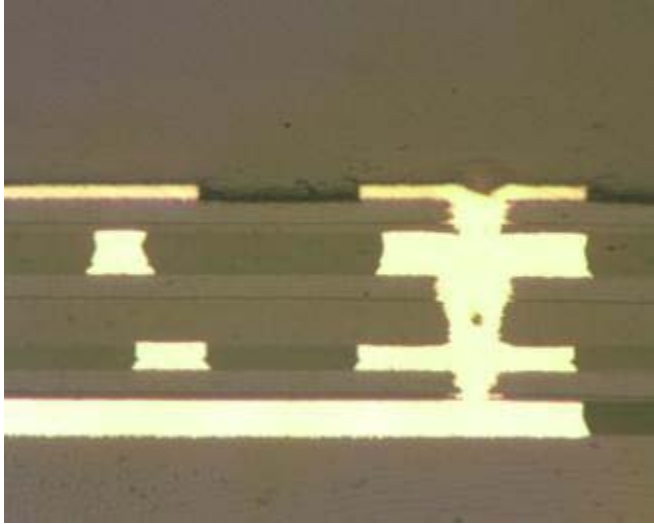
- Advantages
  - High layer count possible with one lamination cycle
- Disadvantages
  - Z-axis interconnect must be formed prior to lamination
  - May require special process/equipment/materials
  - Very thin layers (< 2 mil/50 $\mu$ ) hard to handle

*Zeta can be used in both applications!*

# DK IMPACT ON HDI

- Finer copper traces are great for HDI
  - But harder to produce with high yield
  - As thickness gets reduced, so does Impedance
    - To maintain the same Impedance;
    - Line width must be reduced, or...
    - Dk is reduced, this has the same effect.
    - Zeta produces the same Impedance at half the thickness with the same line width.
  - Thinner structures at the same Impedance have;
    - Easier to drill and plate vias
    - Lower via inductance
    - Lower thermal impedance.

# Zeta<sup>®</sup> for stacked vias



*Sequential lamination is a popular way to make HDI structures. This requires one lamination cycle for each layer.*

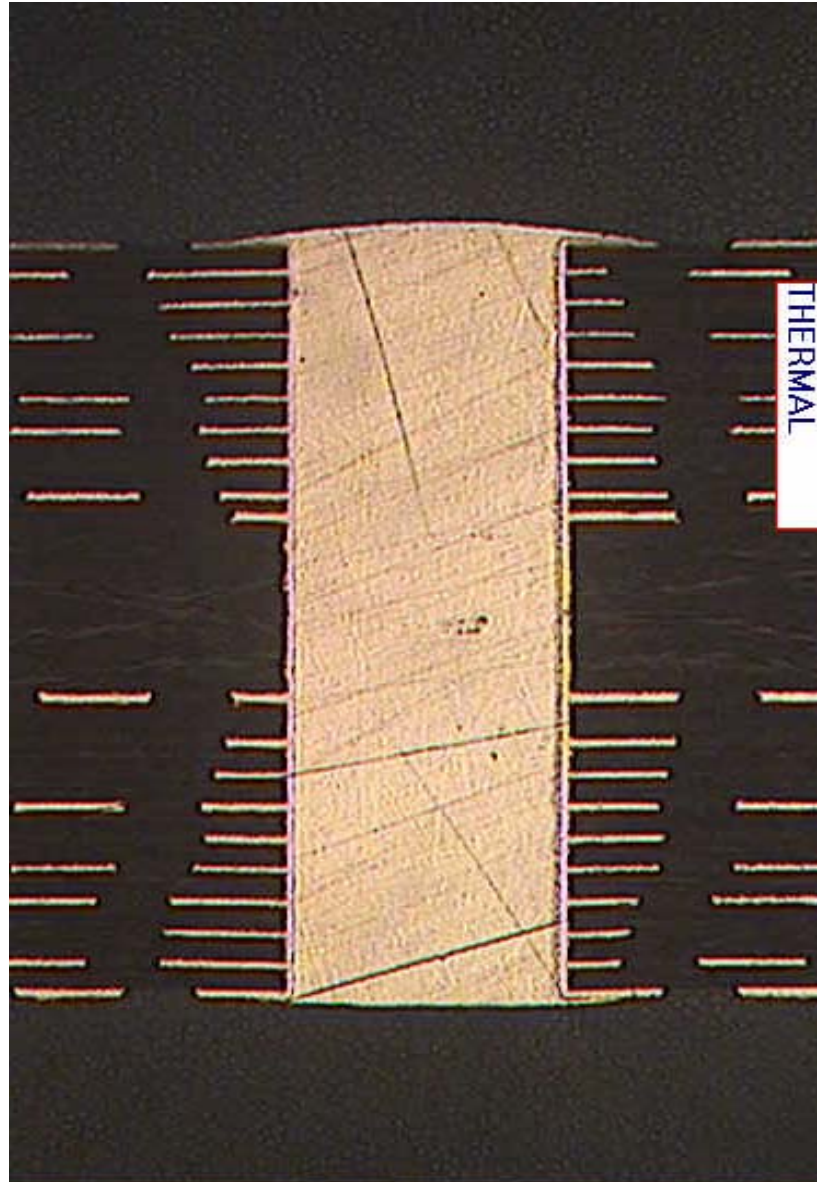
# 9 LAMINATION CYCLES!

Thermal stress coupon

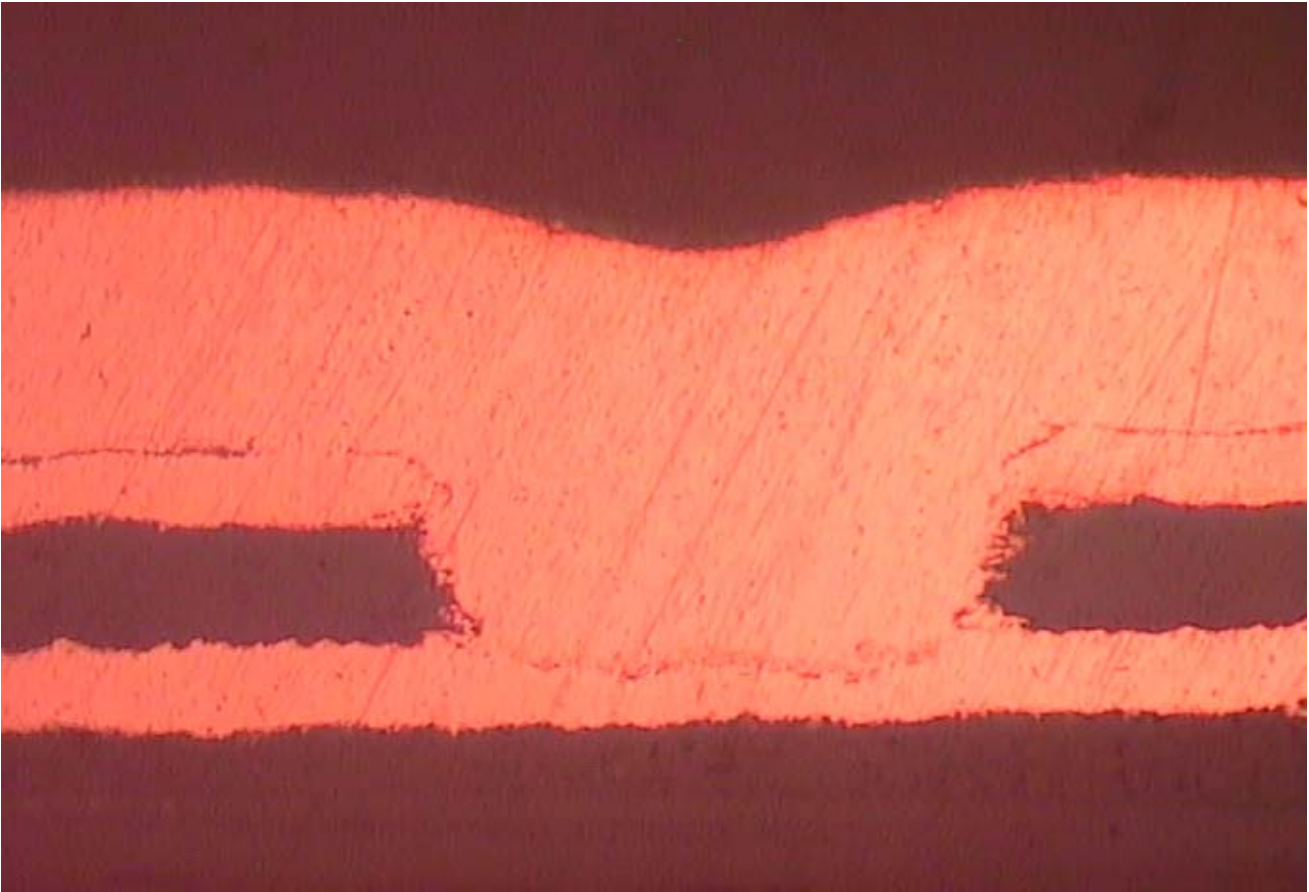
0.008" core + 9 layers  
of Zeta<sup>®</sup> Lam on each  
side.

20 layers

Overall thickness  
0.035"



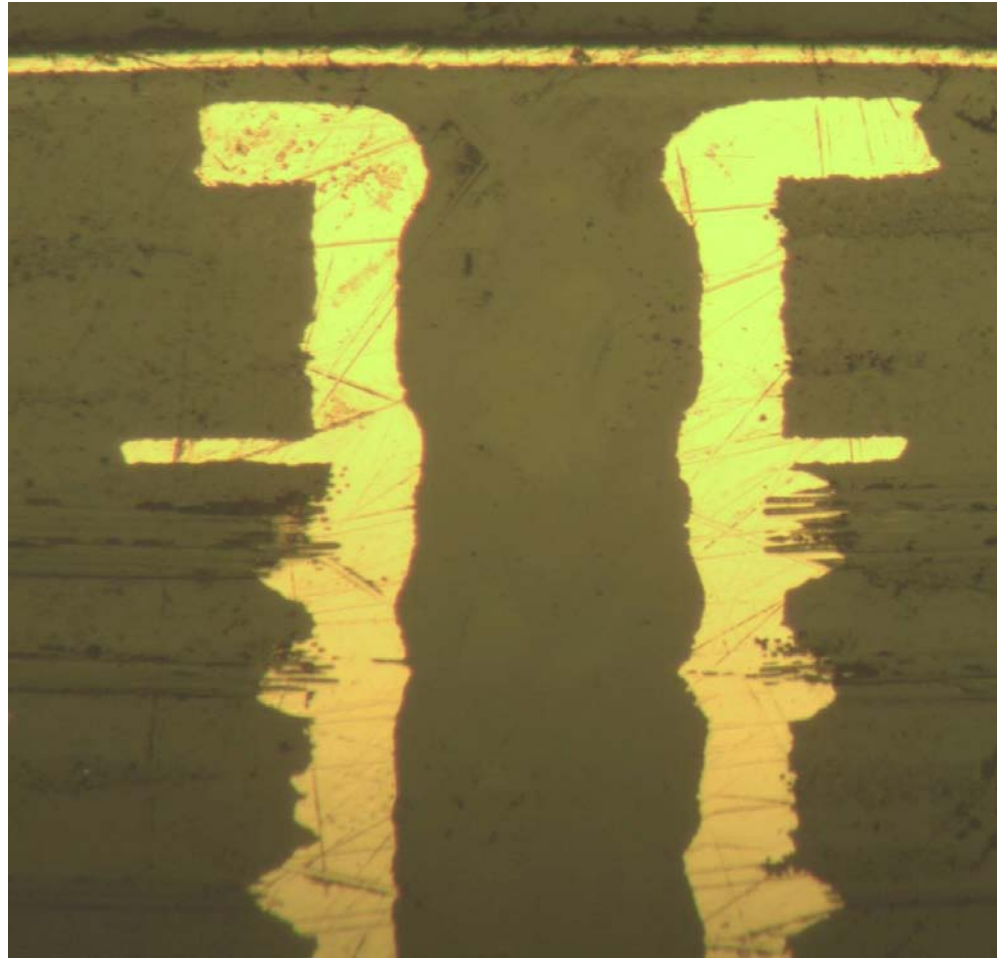
# COPPER VIA FILL WITH STANDARD PLATING BATH





# VIA CAP AND FILL IN ONE STEP

- ❑ Zeta® Bond SE used to fill the via
- ❑ Testing applications eliminating the via fill process steps
- ❑ Zeta® Bond SE resin available in thicknesses to meet many designs in filling via's
- ❑ Glass free allows for more resin to flow into vias



# ZETA® LAM SE STATUS

- First Zeta Lam boards built and shipped February 2009, East Coast PCB shop
- Zeta Lam boards shipped in October 2009, West Coast PCB shop.
- Zeta Lam boards shipped by another West Coast PCB shop in March of 2009.
- Zeta Lam boards built and shipped from Bay Area PCB shop for ongoing design with “Any Layer HDI” using 9 lamination cycles.

# UL STATUS

- Zeta Cap has 94-V0 rating
- Zeta Cap has MOT of 155°C
- Zeta Lam/Bond SE flame testing in process
  - 94-V0 expected
- Zeta Lam/Bond MOT should be 155°C

# IPC

## ○ IPC-4563

- Resin coated copper (RCC)
- Many items are AABUS (as agreed between user and supplier)
- Cover C-stage/B-stage combinations
- Spec allows for many different product types
- This is the best fit for Zeta<sup>®</sup> Lam and ZRC

## ○ IPC-JPCA-4104

- High Density Interconnect (HDI) and Micro Via materials
  - Covers dielectrics, foils and z-axis connections
  - Includes many different types of materials
  - Does not specify C-stage/B-stage combinations

## ZETA MATERIALS HAVE EXCELLENT THERMAL PROPERTIES FOR **GLASS** FREE FILMS

Material	Tg	Td	Z-axis CTE	Comments
Zeta Cap	>300°C	>500°C	19 ppm/°C	Glass free film
Zeta Bond SE	180°C	400°C	60 ppm/°C	Glass free film
Zeta Lam SE	N/A	N/A	40 ppm/°C	Glass free film
Dicy cured Hi Tg epoxy	180°C	300°C	55 ppm/°C	<b>Glass re-enforced 0.020" core</b>
Phenolic Epoxy	180°C	340°C	45 ppm/°C	<b>Glass re-enforced 0.020" core</b>
Flex Epoxy Bonding Film	100°C	285°C	>150 ppm/°C	Glass free film

## ZETA MATERIALS HAVE EXCELLENT ELECTRICAL PROPERTIES FOR **GLASS** FREE FILMS

Material	Dk (2 GHz)	Df	Breakdown Voltage	Comments
Zeta Cap	3.0	0.005	4900 v/mil	Glass free film
Zeta Bond SE	3.2	0.010	2500 v/mil	Glass free film
Zeta Lam SE	3.2	0.010	4900 v/mil	Glass free film
Dicy cured Hi Tg epoxy	4.2	0.014	1000 v/mil	Glass re-enforced 0.020" core
Phenolic Epoxy	4.0	0.021	1350 v/mil	Glass re-enforced 0.020" core
Flex Epoxy Bonding Film	3.2	0.020	3840 v/mil	Glass free film

# THERMAL PROPERTIES

Manufacturer	Part	Thermal Conductivity (W/mK)	Thermal Resistance ( $^{\circ}\text{C cm}^2/\text{W}$ )
Berquist	MP-06503	* 1.3	0.58
	HT-04503	* 2.2	0.32
	HT-07006	* 2.2	0.71
	CML-11006	* 1.1	1.35
Laird	T-LAM SS 1KA04	* 3	0.34
	T-LAM SS 1KA06	* 3	0.52
	T-LAM SS 1KA08	* 3	0.70
	T-LAM SS HTD04	* 2.2	0.46
	T-LAM SS HTD06	* 2.2	0.69
	Integral Tech.	Zeta Bond 1 mil	** 0.58
Zeta Cap 1 mil		** 0.43	0.59
Isola	370HR 106	** 0.44	1.35
	406 106	** 0.28	2.12
Dupont	FR 1 mil	** 0.36	0.71
	Kapton 1 mil	** 0.14	1.82
	LF 1 mil	** 0.22	1.16
	CooLam LX03517016	* 0.8	0.25
	CooLam LX07022016	* 0.8	0.29

\* values sited from manufacturers data sheet

\*\* values from independent lab testing on "C" stage

# HIGH DENSITY INTERCONNECT SUMMARY

- ◉ Questions regarding Zeta<sup>®</sup> HDI applications?



# SUMMARY

ZETA<sup>®</sup> HAS TWO BROAD BASE APPLICATIONS

PAD CRATER FIX

HDI

AS OF NOW, PAD CRATERING HAS NO OTHER FIX

We are being told this by many OEM's

ZETA<sup>®</sup> FOR HDI

MANY COMBINATIONS, APPLICATIONS POSSIBLE

BE CREATIVE! SAMPLES ARE AVAILABLE!