Images of Failures in Microelectronics Packaging and Assembly

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What is this?
Inner Layer Separation

- Between laminate copper and electroless copper
- Found Ca & S residues at failed interface
Inner Layer Separation

- QC coupon mount from PWB fabricator
- “lines of demarcation”
- Missed during routine QC examination
What is this?
Microvia

- This is a poorly fabricated microvia
- There is little or no copper plating connecting to the layer-2 pad
Microvia

- This is a “good” microvia
- There is uniform copper plating connecting to the layer-2 pad
What is this?
Drill Breakout

- The inner layer lands probably should have been larger diameter in this design.
- This condition fails Class 3 criteria in IPC-A-600 (min. annular ring 0.001 in).
What is this?
EOS Failure

- All four Vcc wire bonds are fused open
- There is no damage on the die
- Excessive current failure likely due to latch-up
EOS Failure

- Vcc wire bond is fused open
- Fusing current of 1-mil gold wire is \(~\) 0.75 amps
EOS Failure

- A short segment of metallization was fused open
- Likely caused by a voltage transient
EOS Failure

- A short segment of metallization was fused open
- Likely caused by a voltage transient
EOS Failure

- A short segment of metallization was fused open
- Likely caused by a voltage transient or ESD
EOS Failure

- Gross electrical overstress damage
What is this?
Bond Pad Corrosion

- Contributing causes –
  * moisture
  * “pop-corn” damage
  * internal delam
  * P contamination
Bond Pad Corrosion

- How to avoid –
  * MSD control
- Use CSAM imaging and F/A to diagnose
Bond Pad Corrosion

- Trace of P
- P due to molding compound or residual from IC fab
Bond Pad Corrosion

- Bright spots are Ti-W barrier layer where Al is missing
What is this?
Dendritic Growth on IC Die

- Silver and copper dendrites
- For all the same reasons as bond pad corrosion
Dendritic Growth on IC Die

- ... or most of the same reasons as bond pad corrosion
  - moisture
  - ionic contamination
  - bias
  - internal delam
What is this?
Bond Wire Sweep

- Bond wires are swept by the injection molding compound
What is this?
Gold Embrittlement

- This is gold-embrittled eutectic Sn-Pb solder
- AuSn4 & AuSn2 platelets dispersed throughout the microstructure
Gold Embrittlement

- Theory – the gold-embrittlement caused voiding!
- AuSn4 & AuSn2 platelets trap volatiles
Gold Embrittlement

- Theory – the gold-embrittlement caused voiding!
- AuSn4 & AuSn2 platelets trap volatiles
What is this?
BGA Mechanical Damage

- Probably tool damage
- Most extreme cases had missing balls
BGA Mechanical Damage

- Corner has a missing ball
What is this?
BGA Solder Joint Failure

- BGA solder joint failed at the BGA substrate
- Entrapped material includes flux and mask constituents
- Probably flux and mask are chemically incompatible
BGA Solder Joint Failure

- This is a different example
- Entrapped material likely debris from plastic trays
BGA Solder Joint Failure

- This is the fracture surface at the BGA substrate (different location)
- IPC specifications allow up to 25%
What is this?
ENIG Black Pad Syndrome

- Brittle fracture at the solder/PWB pad interface
- More specifically between the Ni$_3$Sn$_4$ IMC layer and the P-rich EN
ENIG Black Pad Syndrome

- Very fine line brittle fracture at the solder/PWB pad interface
ENIG Black Pad Syndrome

- Very thin (~ 0.25 micron) P-rich EN layer in contact with the Ni$_3$Sn$_4$ IMC layer
ENIG Black Pad Syndrome

- 2nd example
- Very thin (~ 0.25 micron) P-rich EN layer in contact with the Ni3Sn4 IMC layer
ENIG Black Pad Syndrome

- ~18 wt% P at the fracture surface versus 7 – 9 wt% P for EN bulk
ENIG Black Pad Syndrome

- IG spiking
- Hyper-etching of EN in IG bath
ENIG Black Pad Syndrome

- 2\textsuperscript{nd} example
- IG spiking
- Hyper-etching of EN in IG bath
What is this?
Failed SMD Inductor

- Discoloration of magnet wire
- Open circuited coil
Failed SMD Inductor

- Encapsulant voids around magnet wire
- Magnet wire cross-section reduced due to corrosion
Failed SMD Inductor

- Corrosion due to Cl & Br from activated flux that wicked into the coil
Failed SMD Inductor

- Corrosion due to Cl & Br from activated flux that wicked into the coil
What is this?
Failed Resistor Network Joint

- Classic thermal fatigue failure
- Voids may be a contributing factor
Failed Resistor Network Joints

- Classic thermal fatigue failure
- Thermal expansion mismatch too large
- Failed after ~ 5 years of service
What is this?
MLCC Knit Line Failure

- MLCC manufacturing defect
- Crack propagates and crosses plates causing electromigration short
MLCC Knit Line Failure

- Delamination between plate and dielectric
MLCC Dielectric Voids

- Void bridges plates and creates electromigration path
MLCC Dielectric Voids

- Another example of MLCC dielectric voids
What is this?
TSOP Electromigration Failure

- Electrical leakage failures
- No Clean Flux, but likely activated flux used in touch up
TSOP Electromigration Failure

- Pb dendrites grow between signals and short them out
- Never mix No-Clean flux and activated flux
TSOP Electromigration Failure

- Its even growing across the mold flash up by the package body!
TSOP Electromigration Failure

- There is nothing quite like a pretty picture of a Pb-dendrite
CONCLUSIONS

- Dendrites? Go ahead, make my day …
- Bond pad corrosion? Bring it on!
- Black pad syndrome? Not a HASL

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