Reliability Testing of Advanced Area Array Packages (AAP) for Space

by

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California Institute of Technology

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Outline

- Package
  - Definition
  - Trend
- Hierarchy of req & reliability testing
  - Mission/2nd level
  - Package/Part
- Advanced AAP reliability
  - FCBGA
  - Chip capacitor
  - LGA/CGA assembly
- Summary/Future Activities

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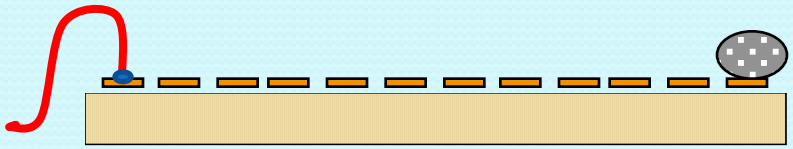
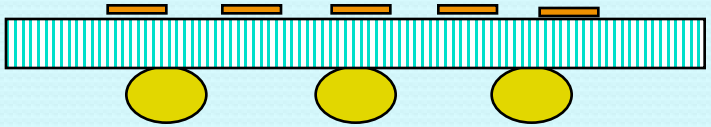
Single Package Concept

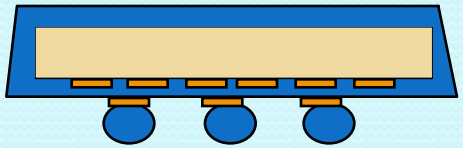
- Die Tight Pitch
- Al Pad- Non Reflow

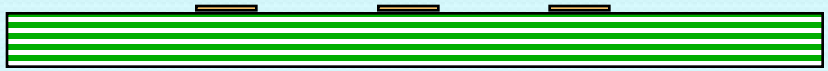


- Interposer
  - Polymer, Ceramic, Flex
  - Cu:Ni:Au Pad



- Wafer
  - Pitch limitation





- Norm Pitch for PWB
  - 0.4-1.27 mm

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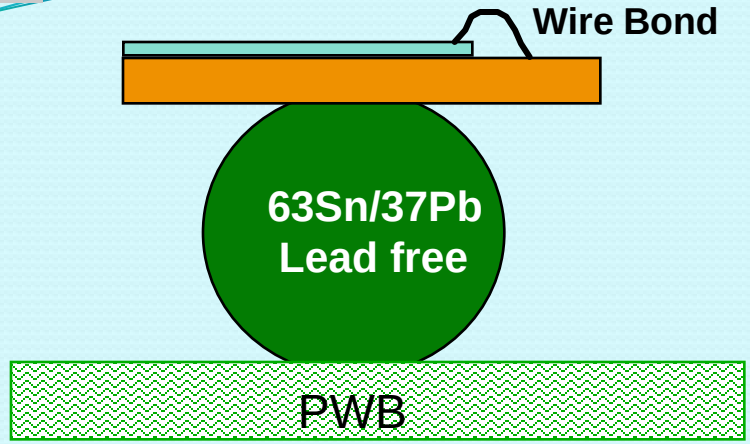
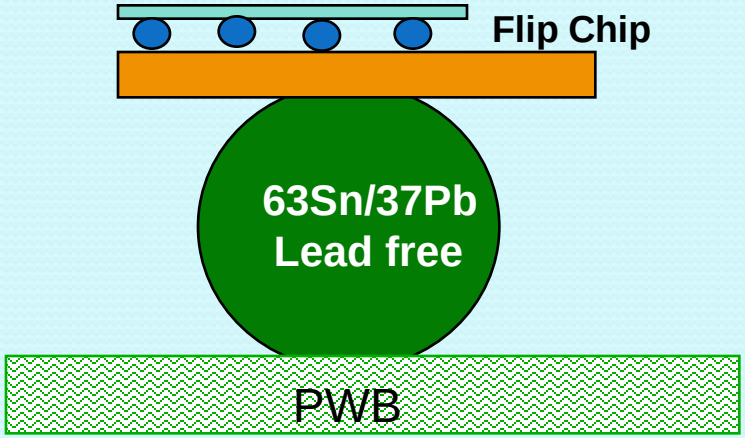
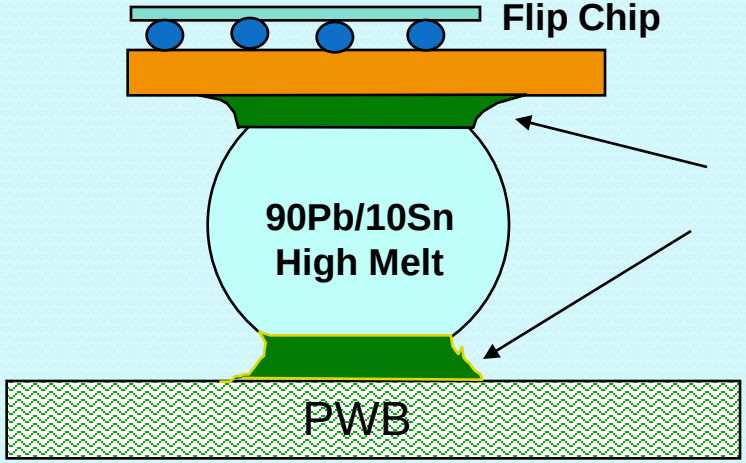
Area Array FCBGA/CGA Package Technology



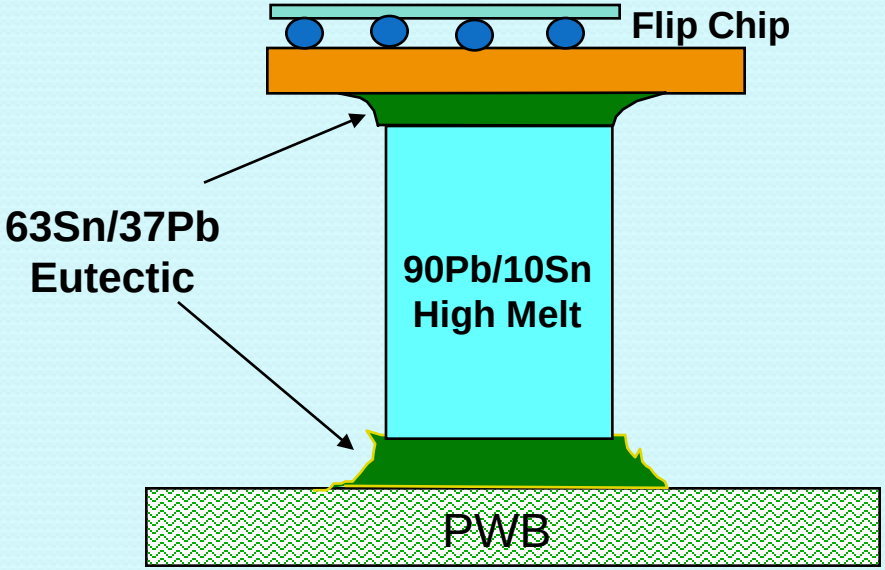
Plastic BGA (PBGA)



Flip Chip BGA (FCBGA)

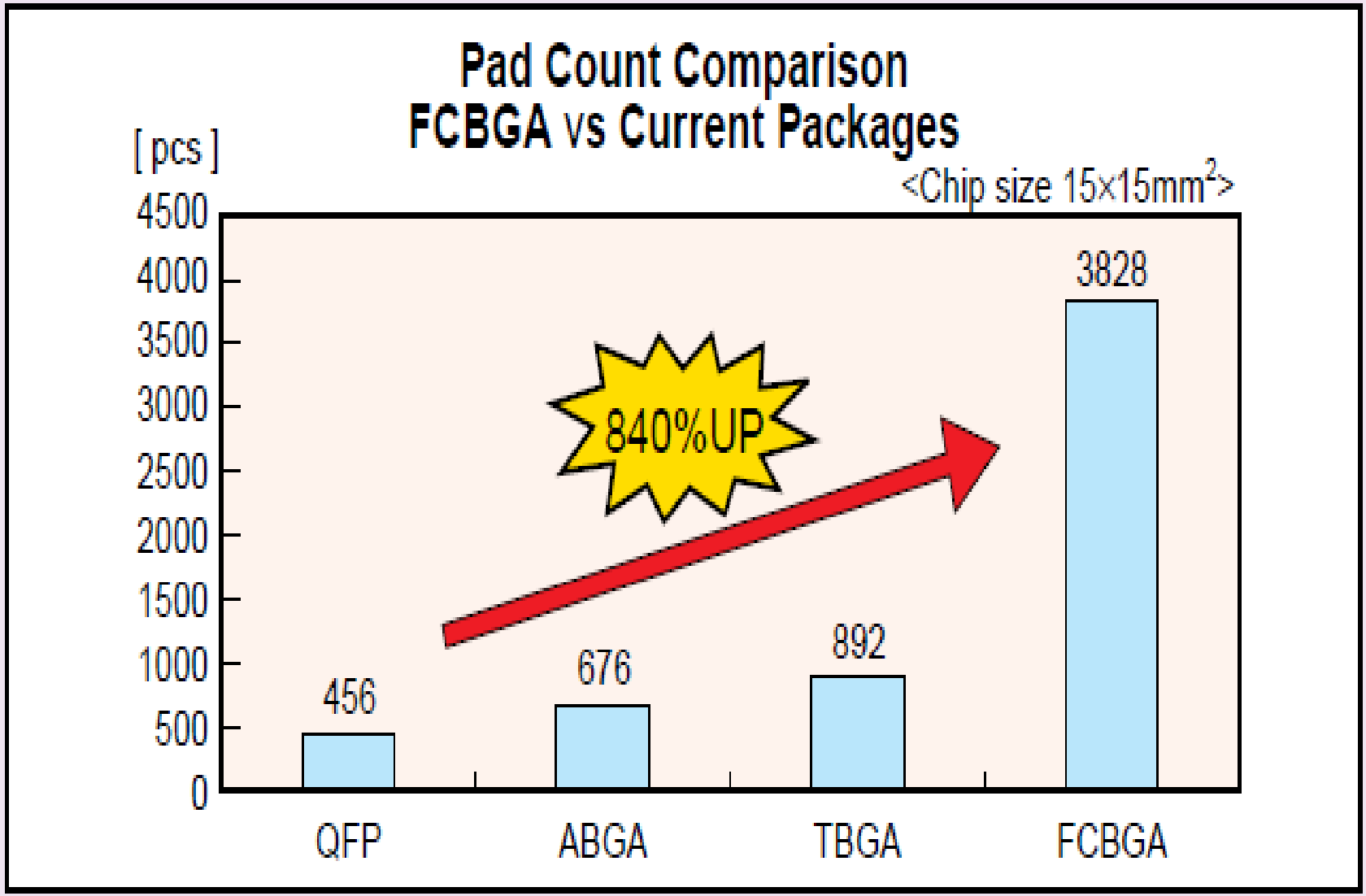


Ceramic BGA (CBGA)



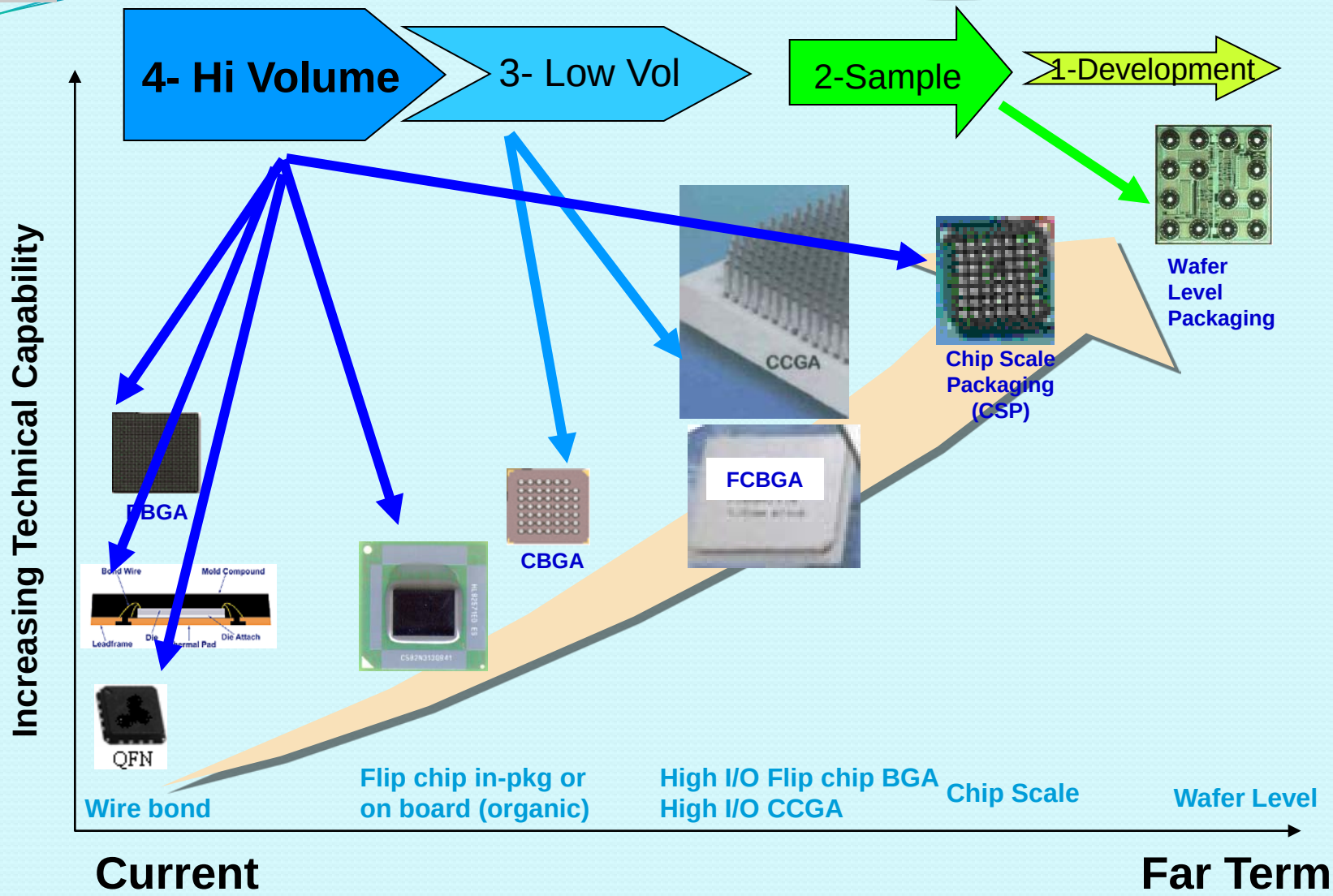
Column CGA (CCGA)

FCBGA Only Choice for High I/Os >1000



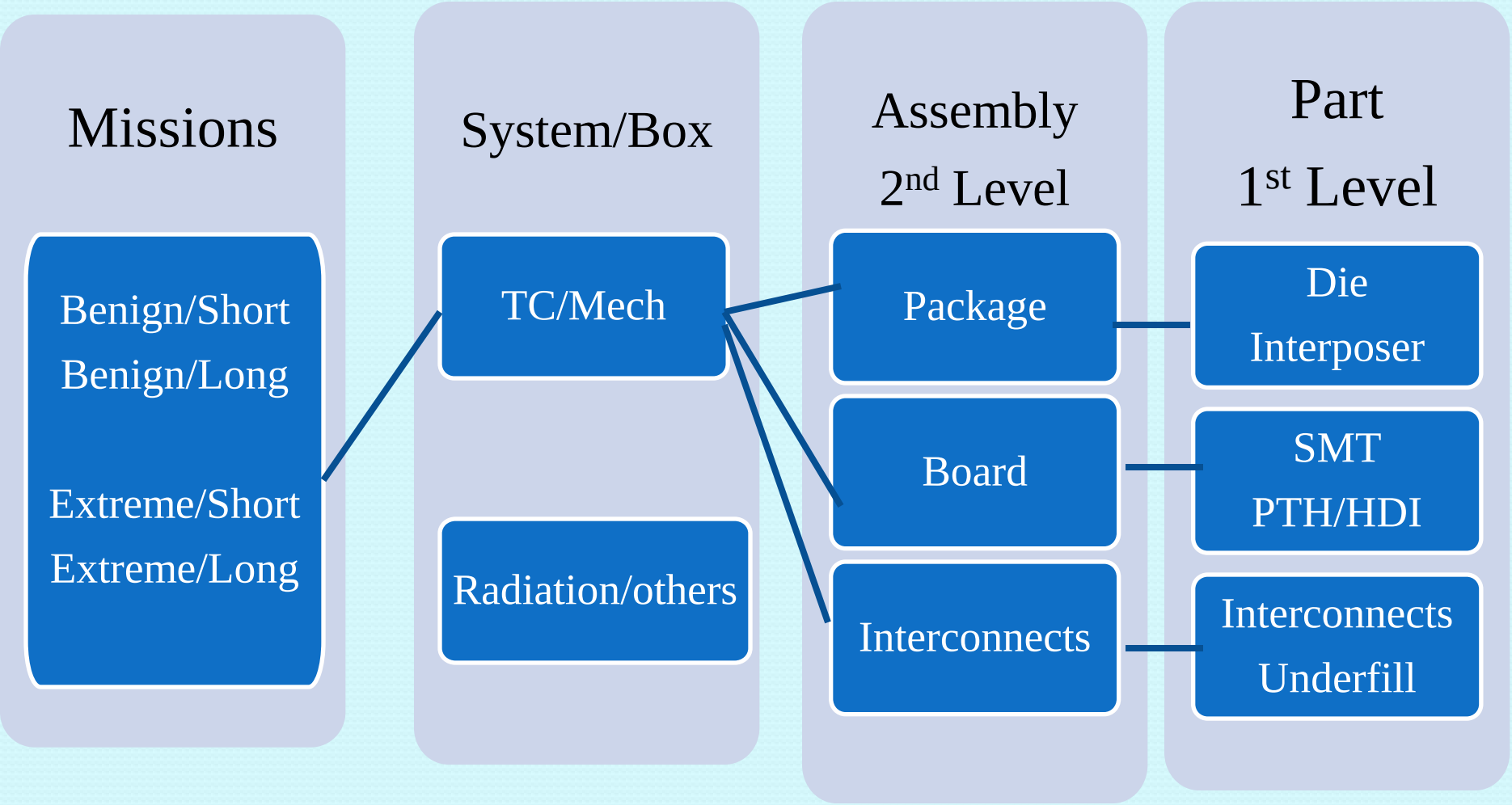
http://america2.renesas.com/docs/files/FCBGA_brochure.pdf

Single Chip Packaging Roadmap



D. Gerke/R. Ghaffarian, NASA NEPP Workshop, June 2010

Hierarchy of Reliability Testing



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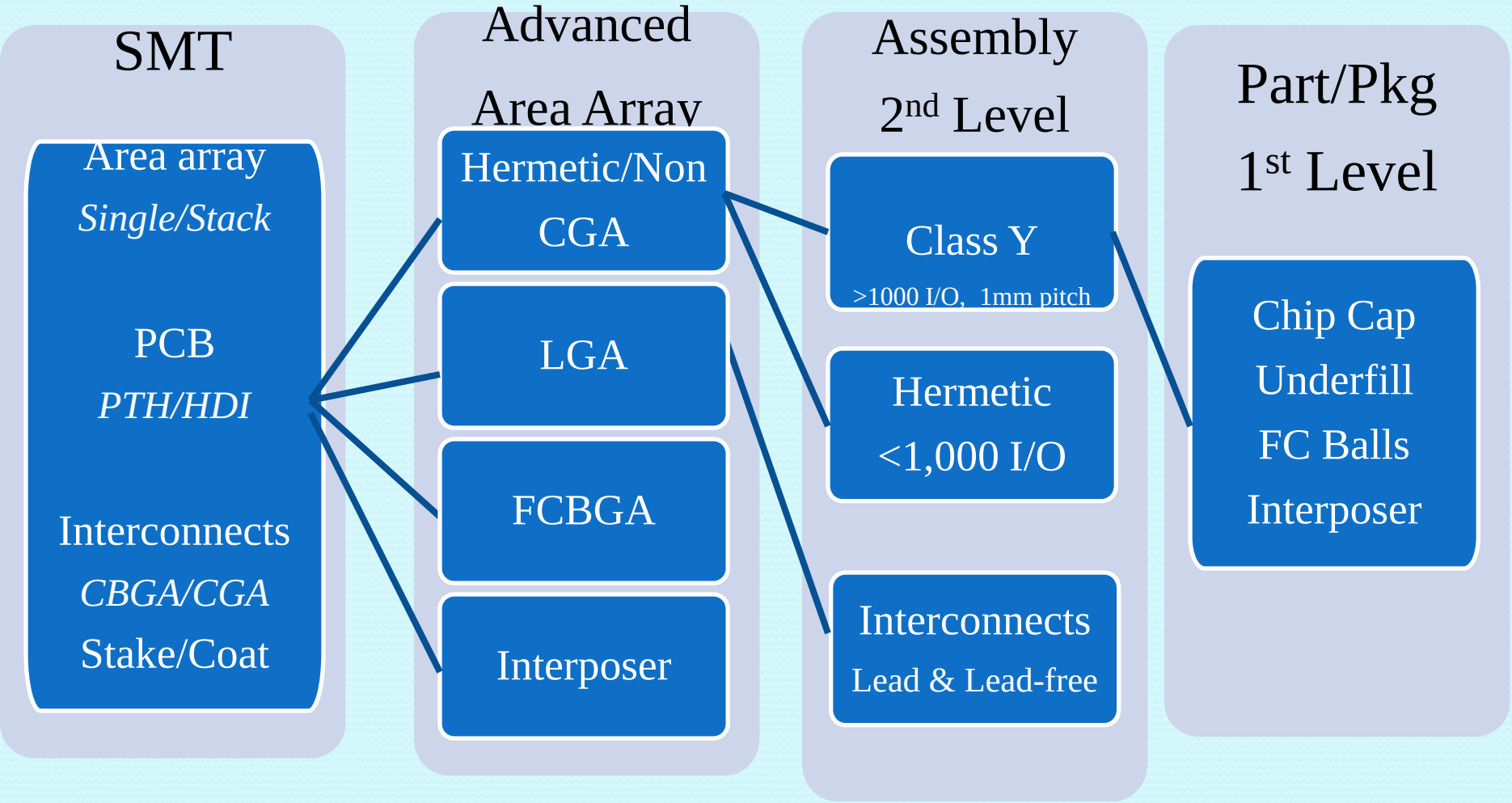
System/Pkg Reliability Testing



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Reliab Testing of Advanced AAP

FCBGA

- Assembled lead & lead-free
- Completed thermal cycles/Drop Test
- X-ray & X-sectional evaluation

LGA

- Column attach/pull test/age-pull test
- CGA (two types) assembly onto PCB
- LGA version

CGA

- Package/capacitors reliability evaluation
- Successful Assembly
- Environmental tests

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PBGA to FCBGA

- Limitation of PBGAs
  - Wire bonds only periphery
    - Solution: Tier wire bonding, still limit for higher I/Os
  - Higher speed need
    - No solution
- FCBGA advantages
  - Use area of die, larger I/Os than periphery
  - Higher speed
    - Short electrical path: Low capacitance, inductance, resistance
    - Accommodate higher I/Os >1000

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PBGA to FCBGA

- FCBGA advantages
  - Heat dissipation
    - Die backside is exposed & good for heat spreader
    - Heat spreader as hermetic seal
  - Additional cost due to underfill/heat spreader
  - No standard for high-reliability applications
- FCBGA drawbacks
  - Heat spreader
  - Underfill/hermeticity
  - Another AAP/integrity verification

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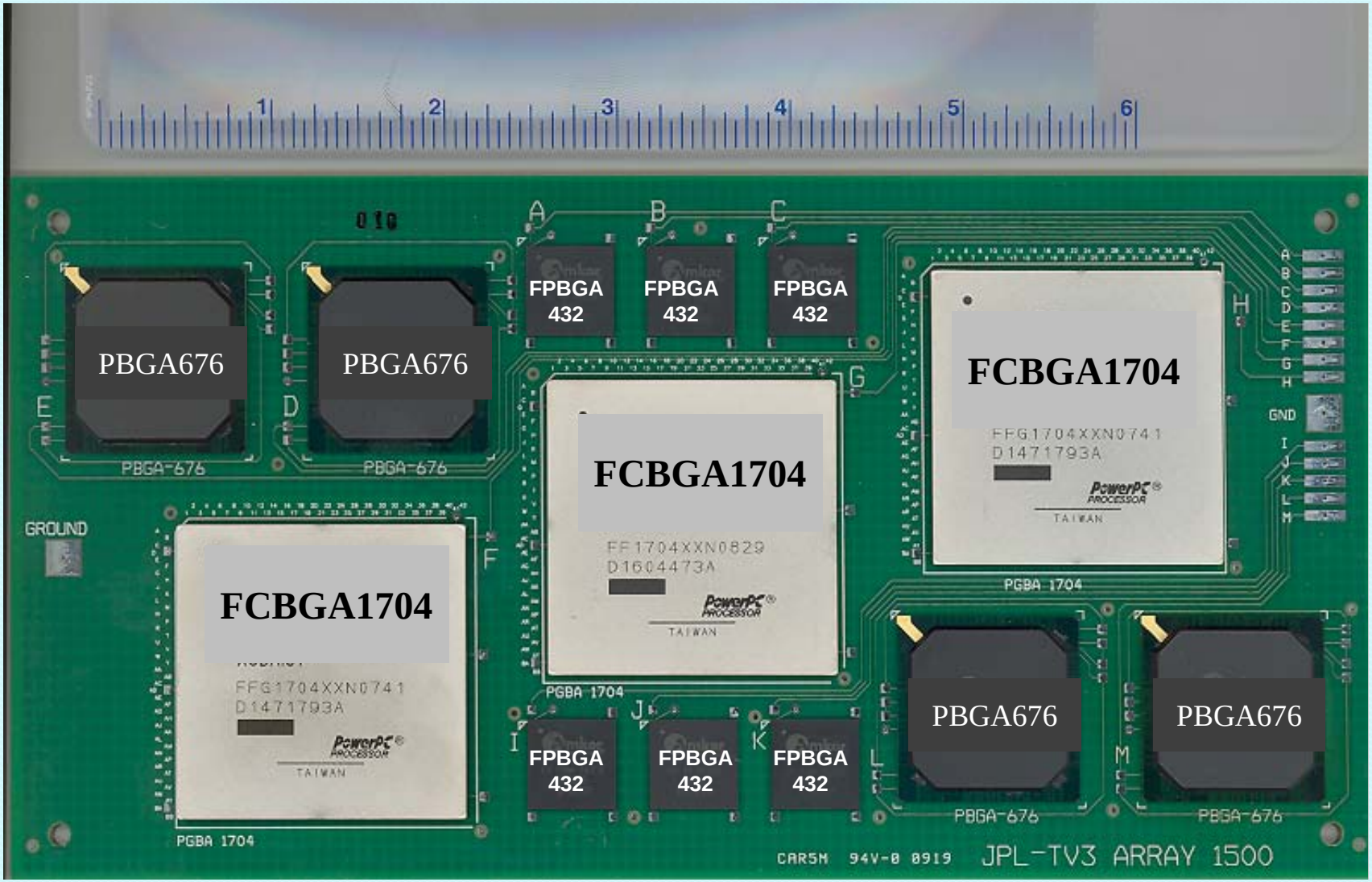
Test Vehicle: FCBGA 1704 , PBGA676, FPBGA 432



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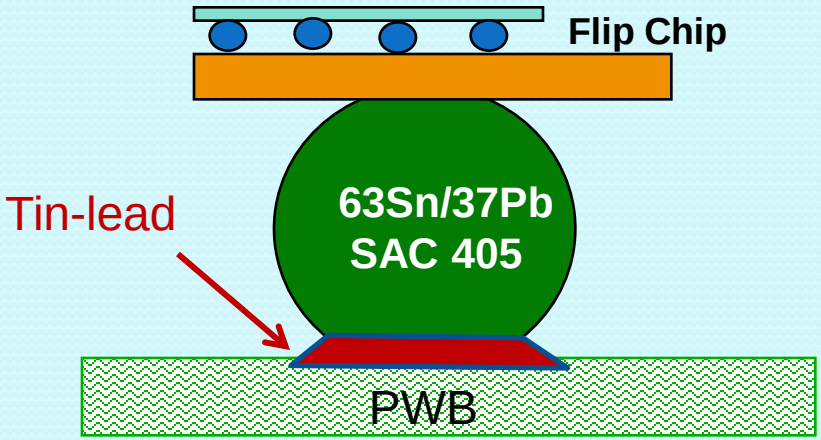
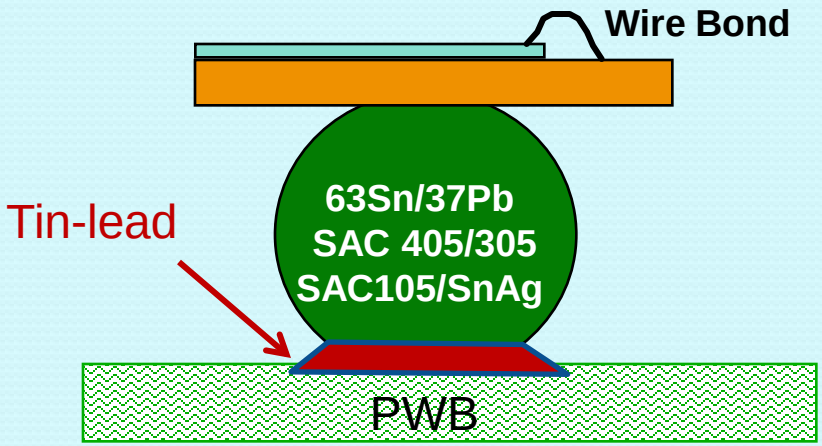
Flip Chip & Wire Bond BGA

- Flip Chip BGA
  - FCBGA 1704 I/O 1.0 mm pitch



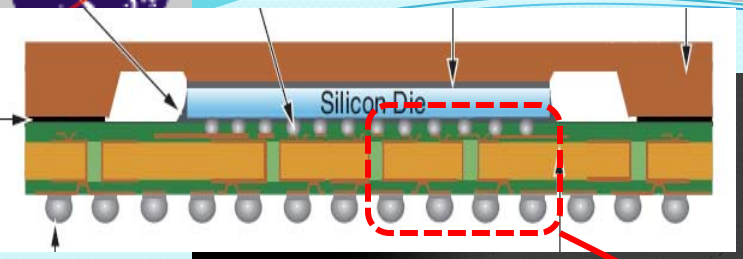
Flip Chip BGA (FCBGA)

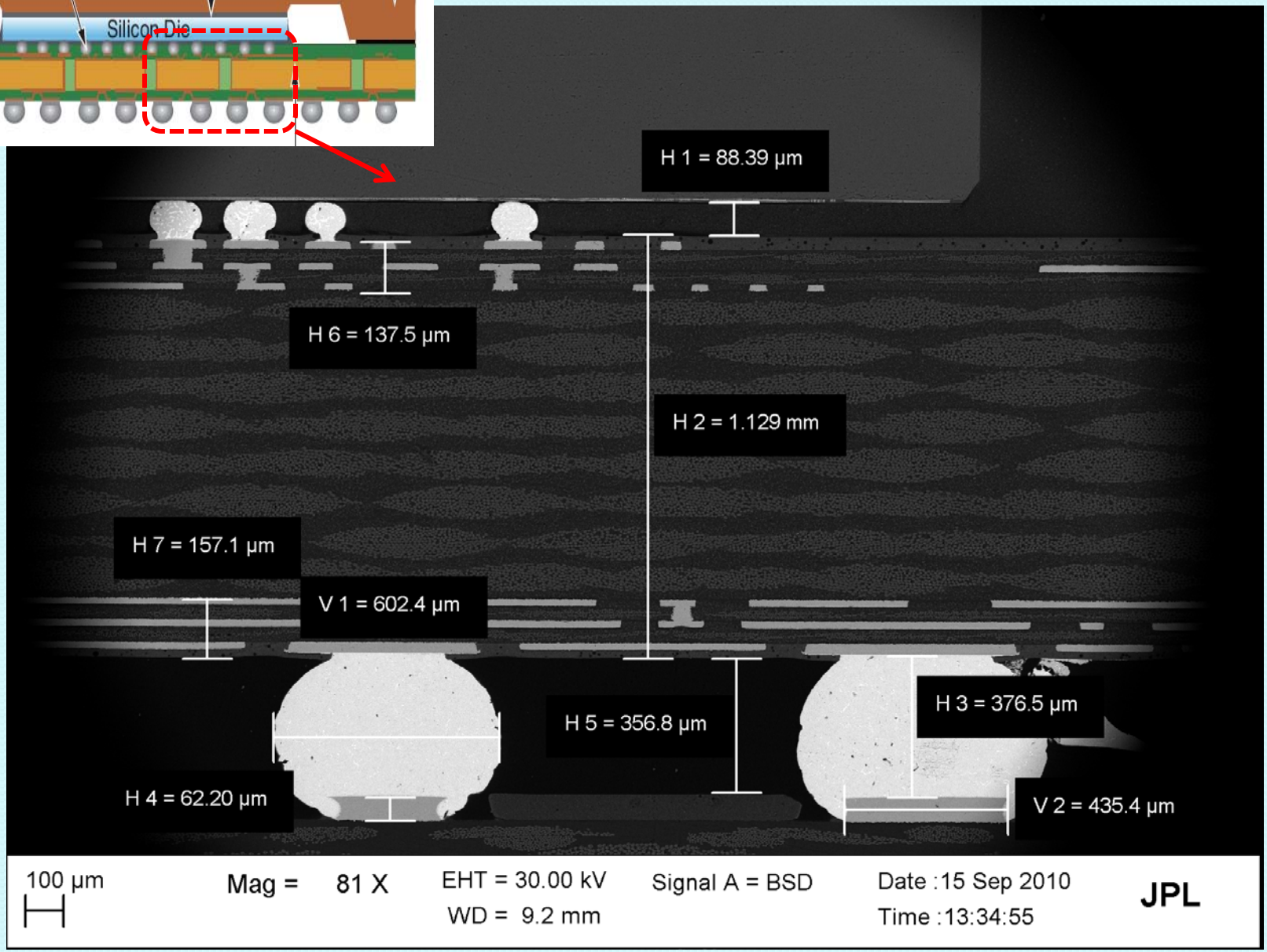
- BGA- Wire bond:
  - PBGA 676 I/O 1.0 mm /control
  - FPBGA 432 I/O 0.4 mm/state-of-the-art



Plastic BGA (PBGA)

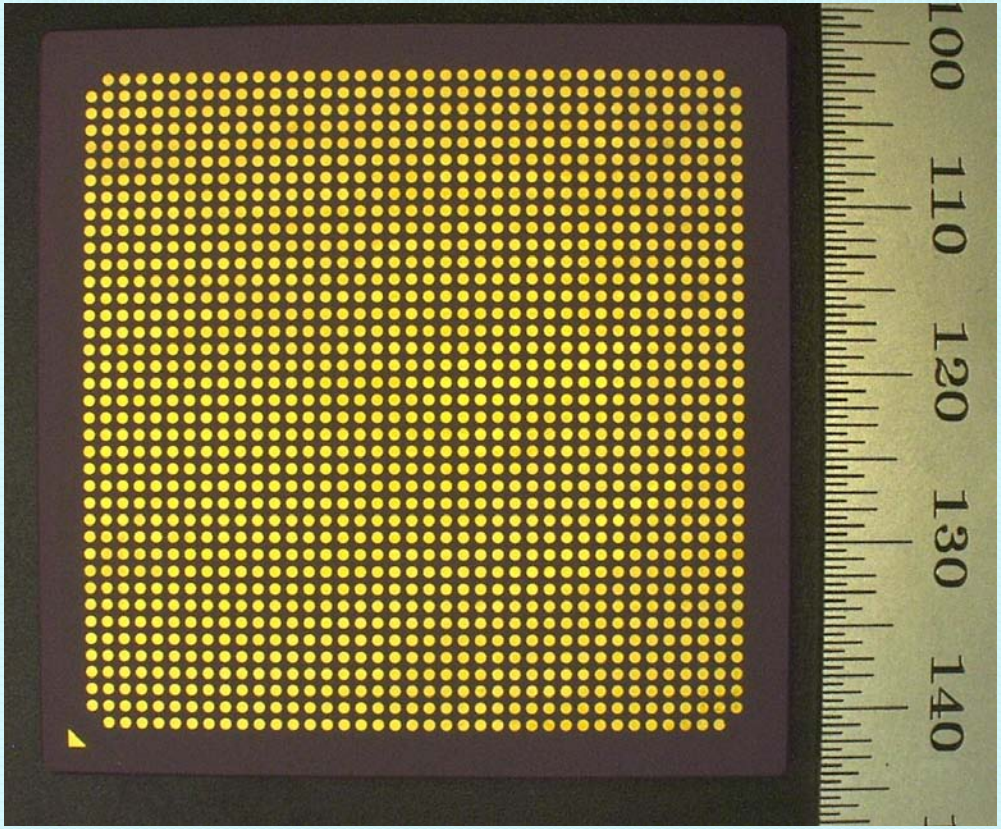
SEM X-section Micrograph for FCBGA after Thermal Cycles





LGA Reliability Testing Methods

- Column attach: Two types
  - Pull test/Age-pull test
- CGA versions assemble onto PCB
- LGA version



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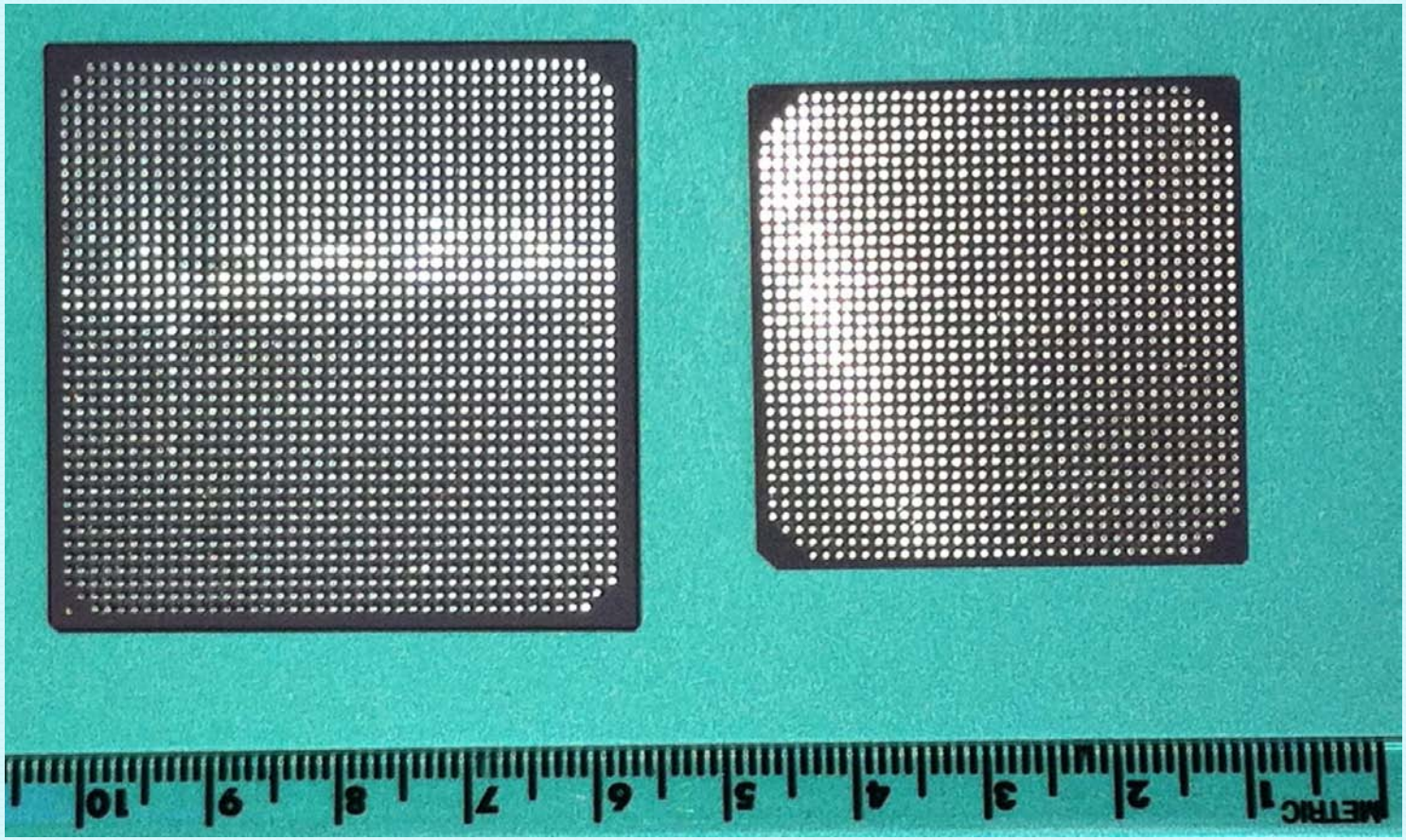
CGA Reliability Testing

- Package/chip capacitor reliability evaluation
- Assemble onto PCB
- Environmental testing



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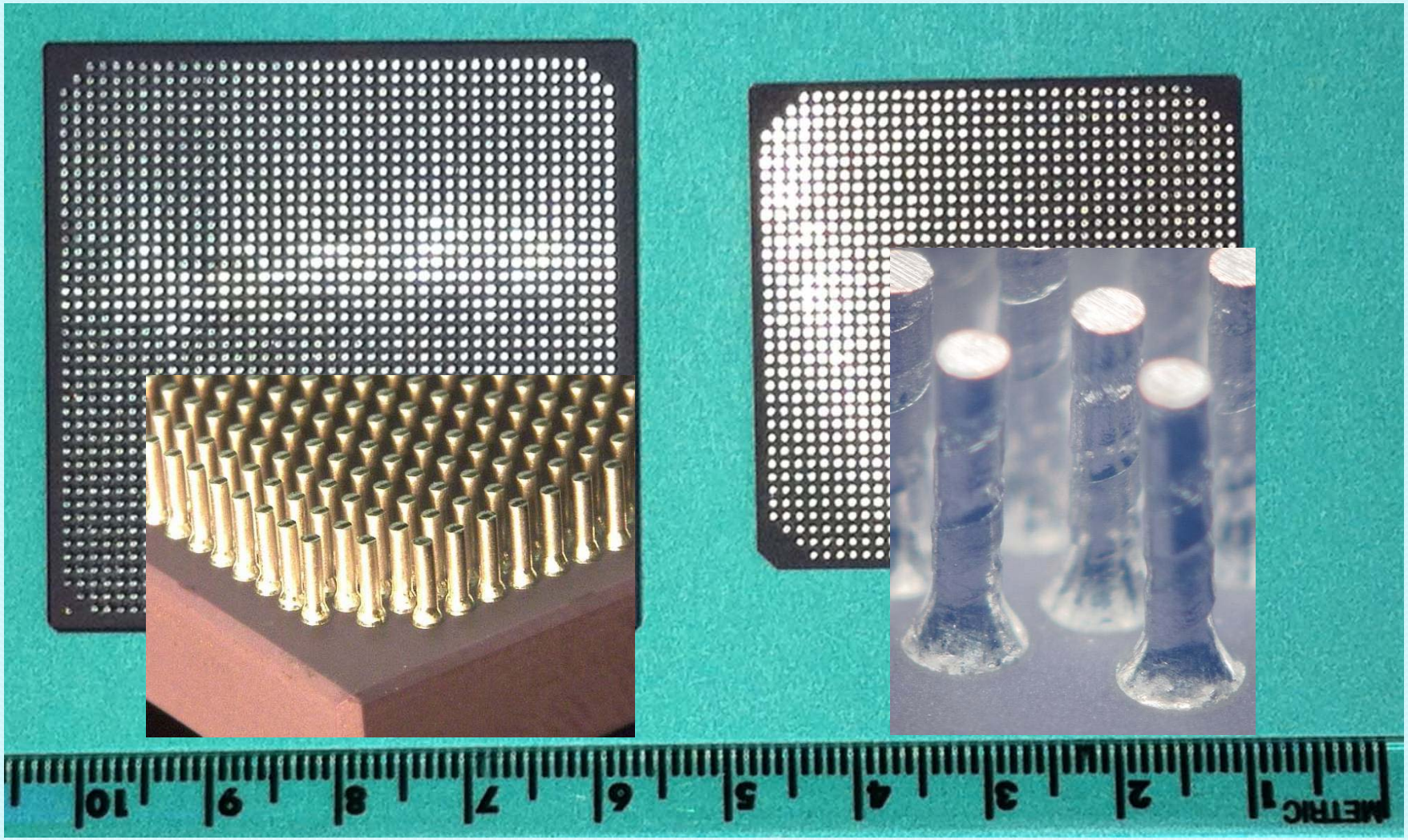
Two CGAs/Two Column Types



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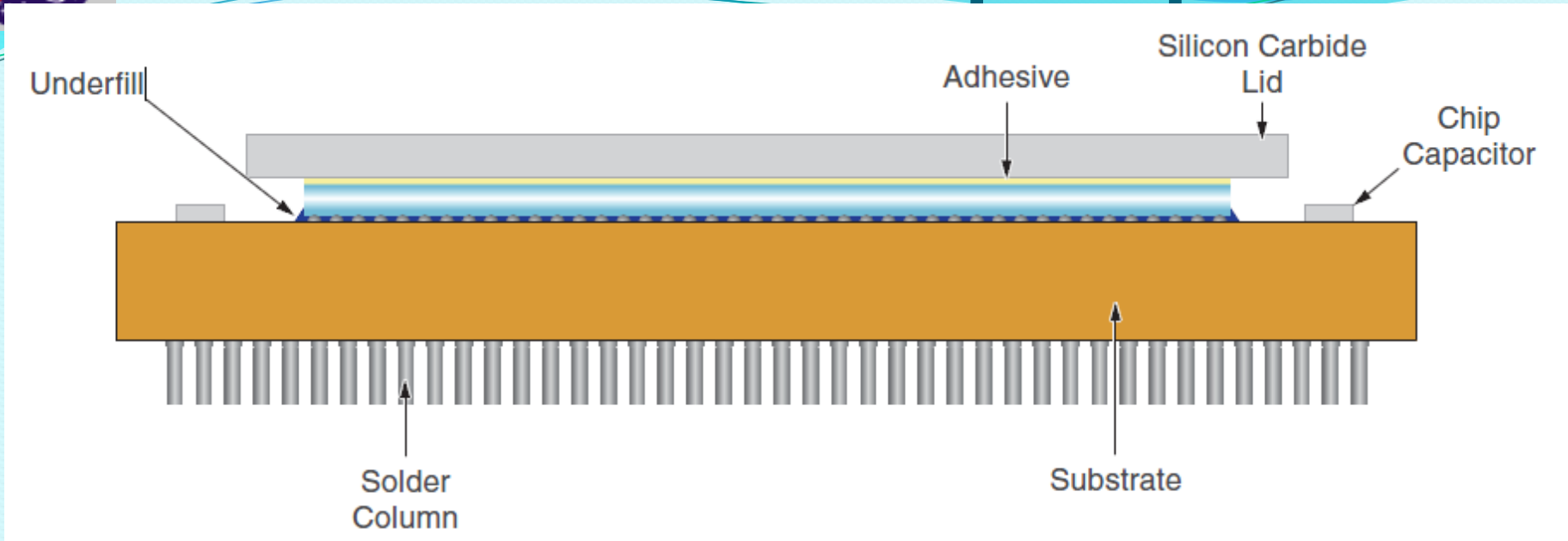
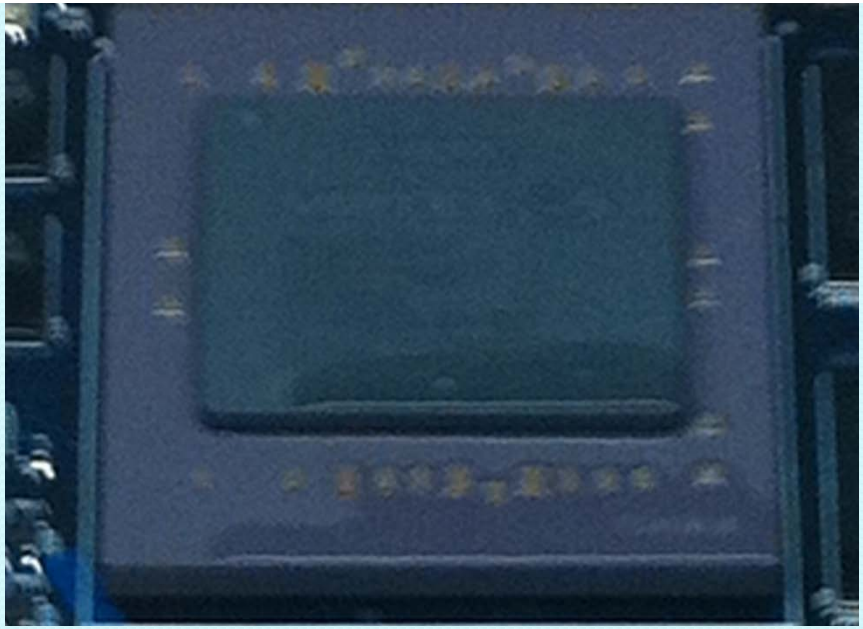
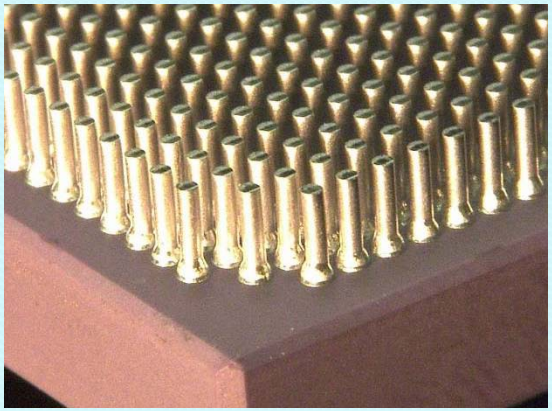
CGA with 31 Chip Capacitors







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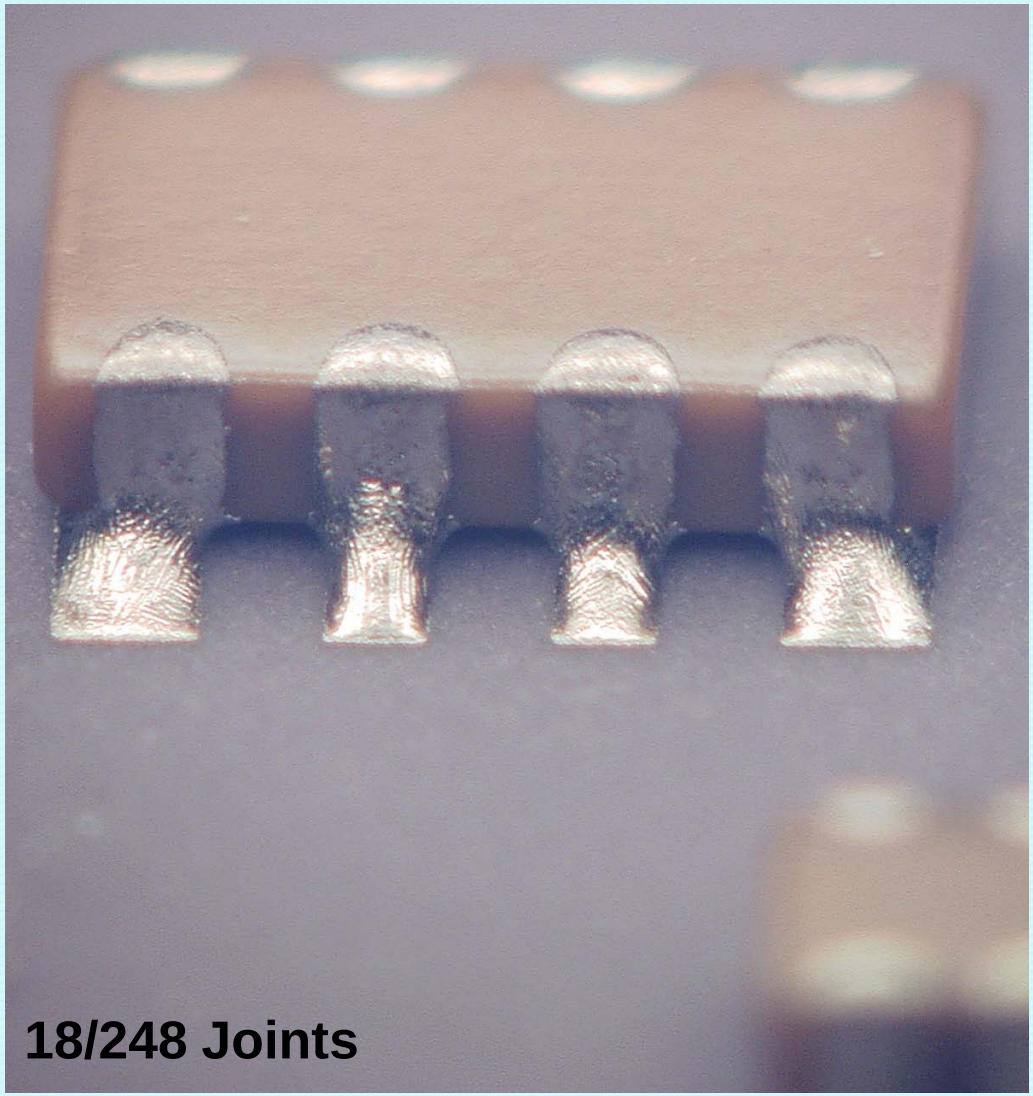
Chip Capacitor Solder Joints

Received Dec 2010



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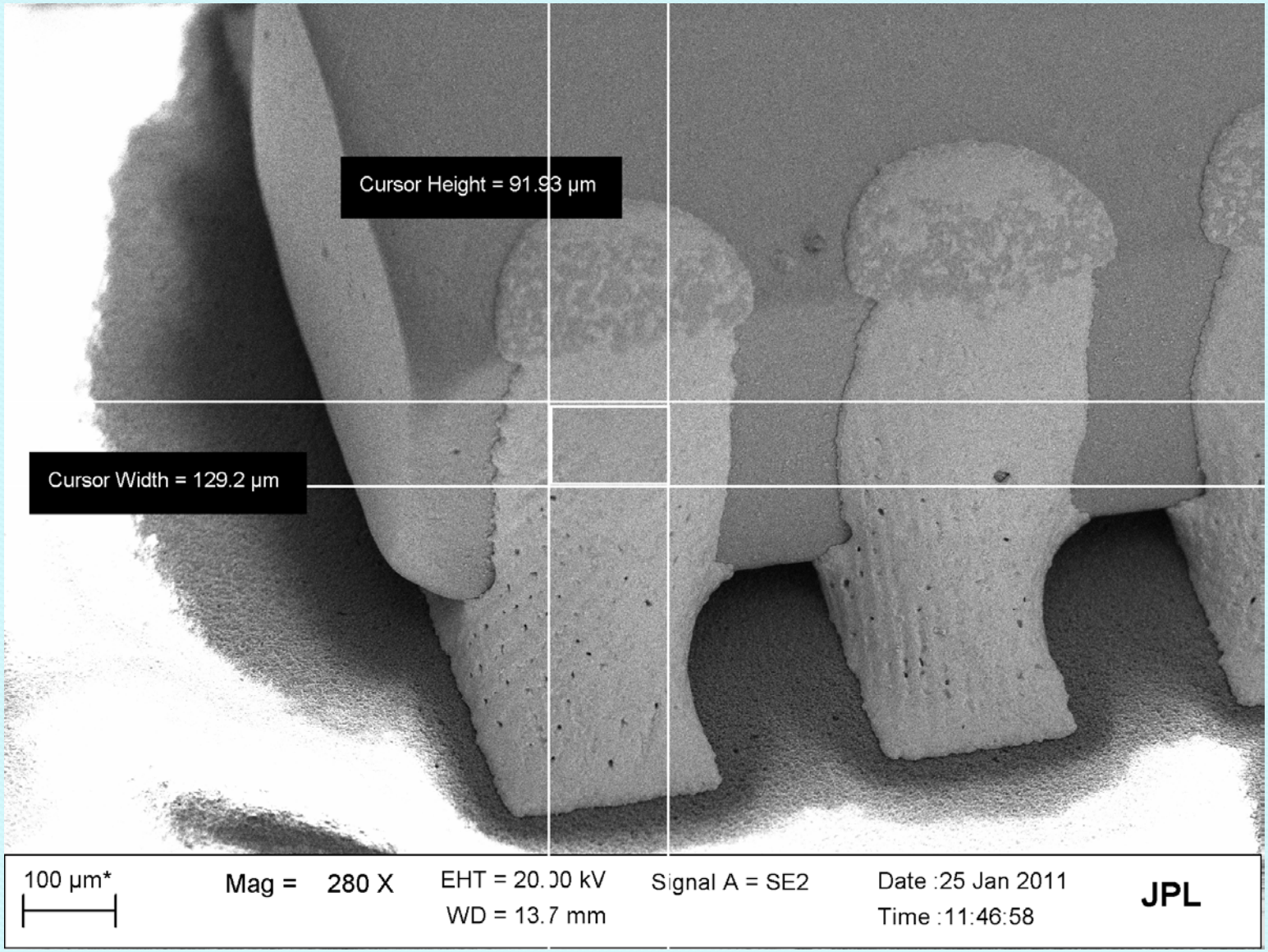
SEM of a Capcitor



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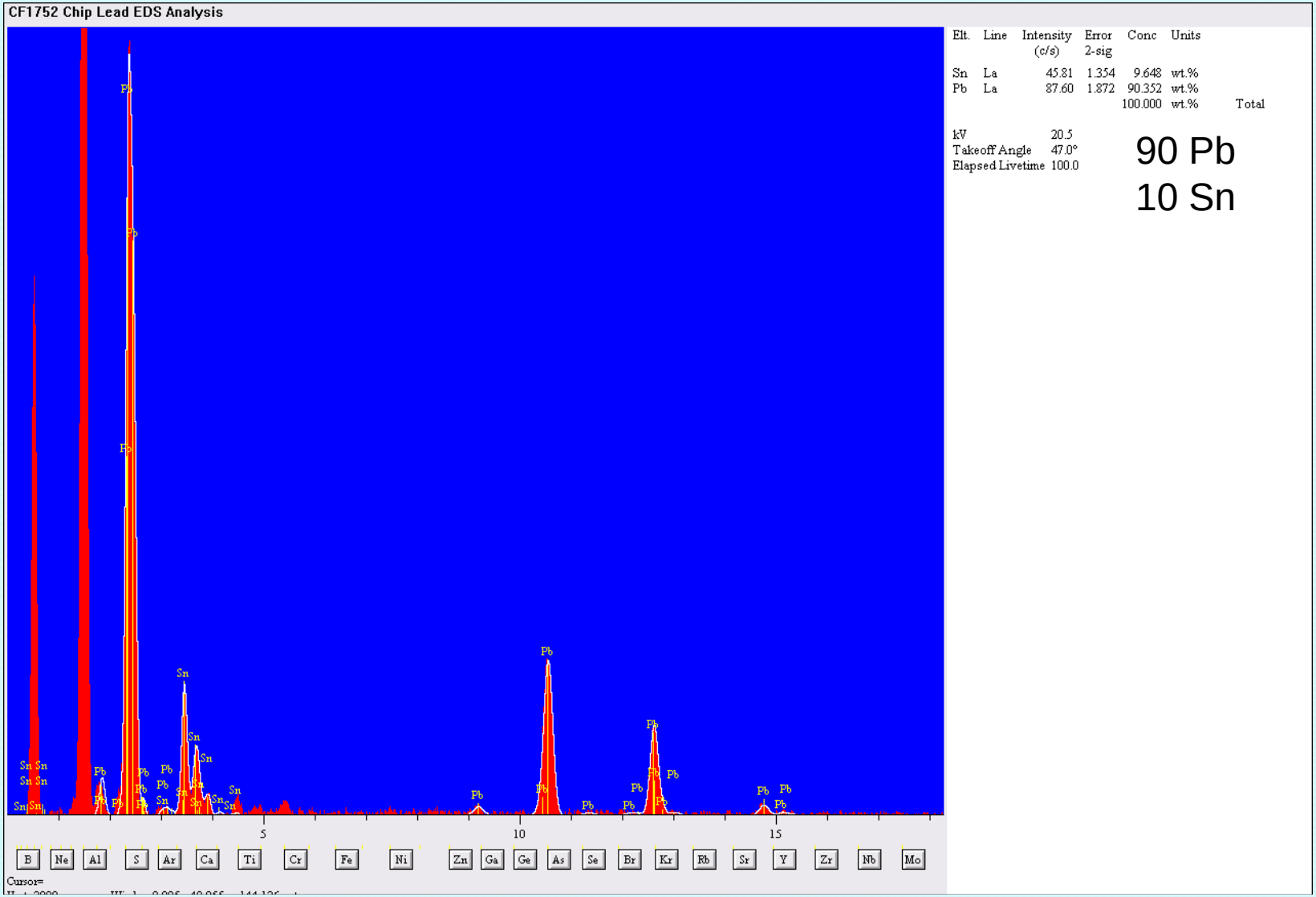
Solder Joint Composition



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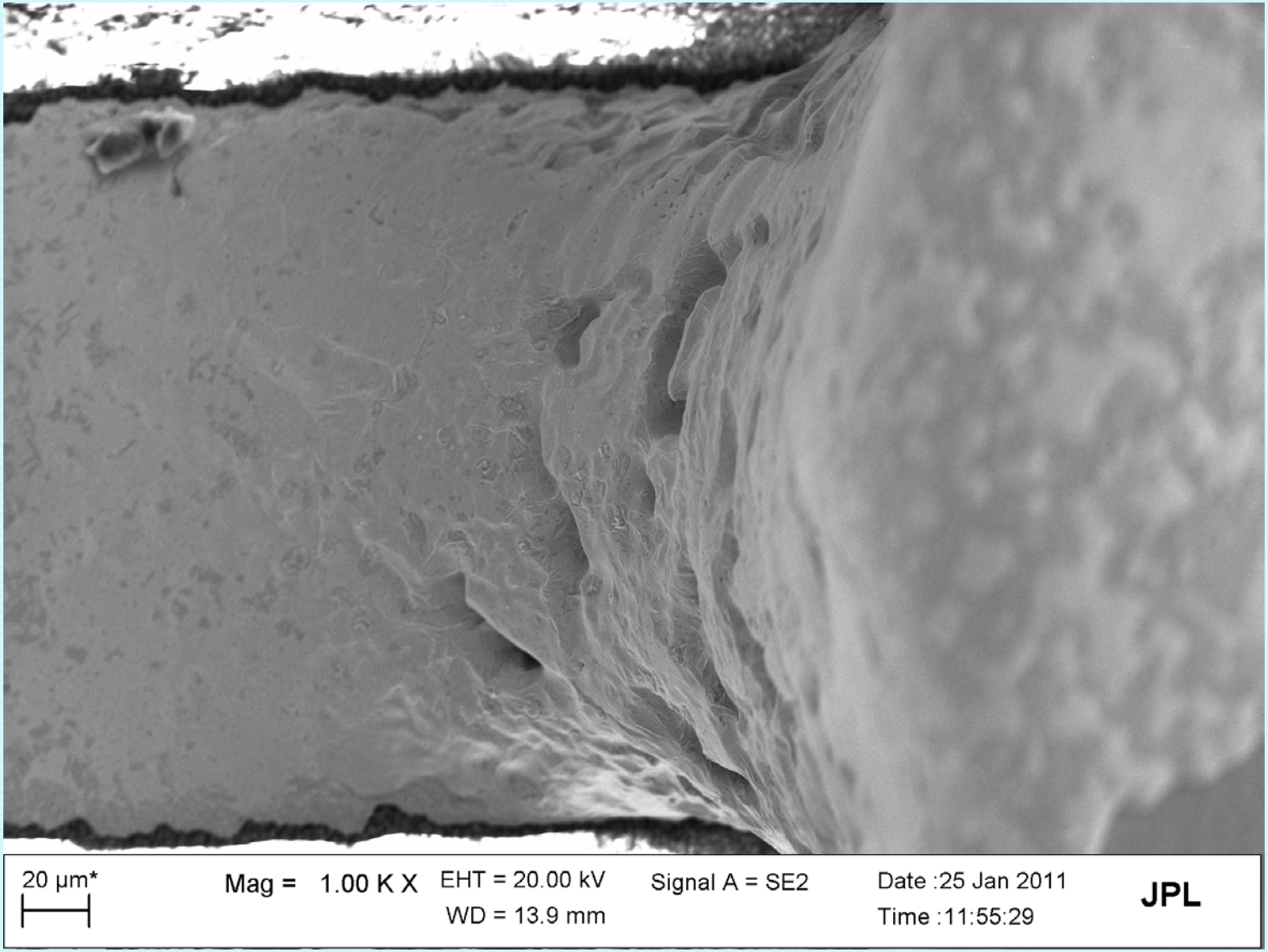
SEM of Capacitor Solder Joint



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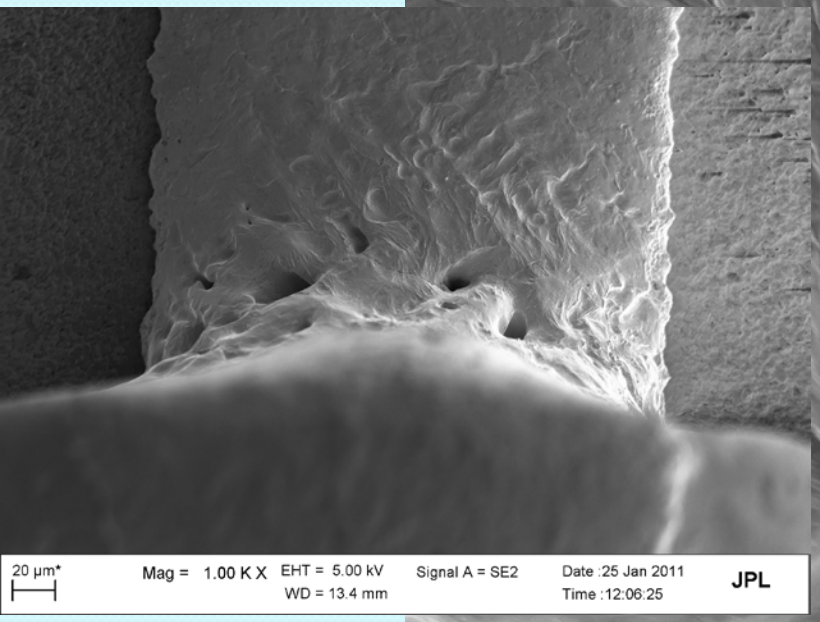
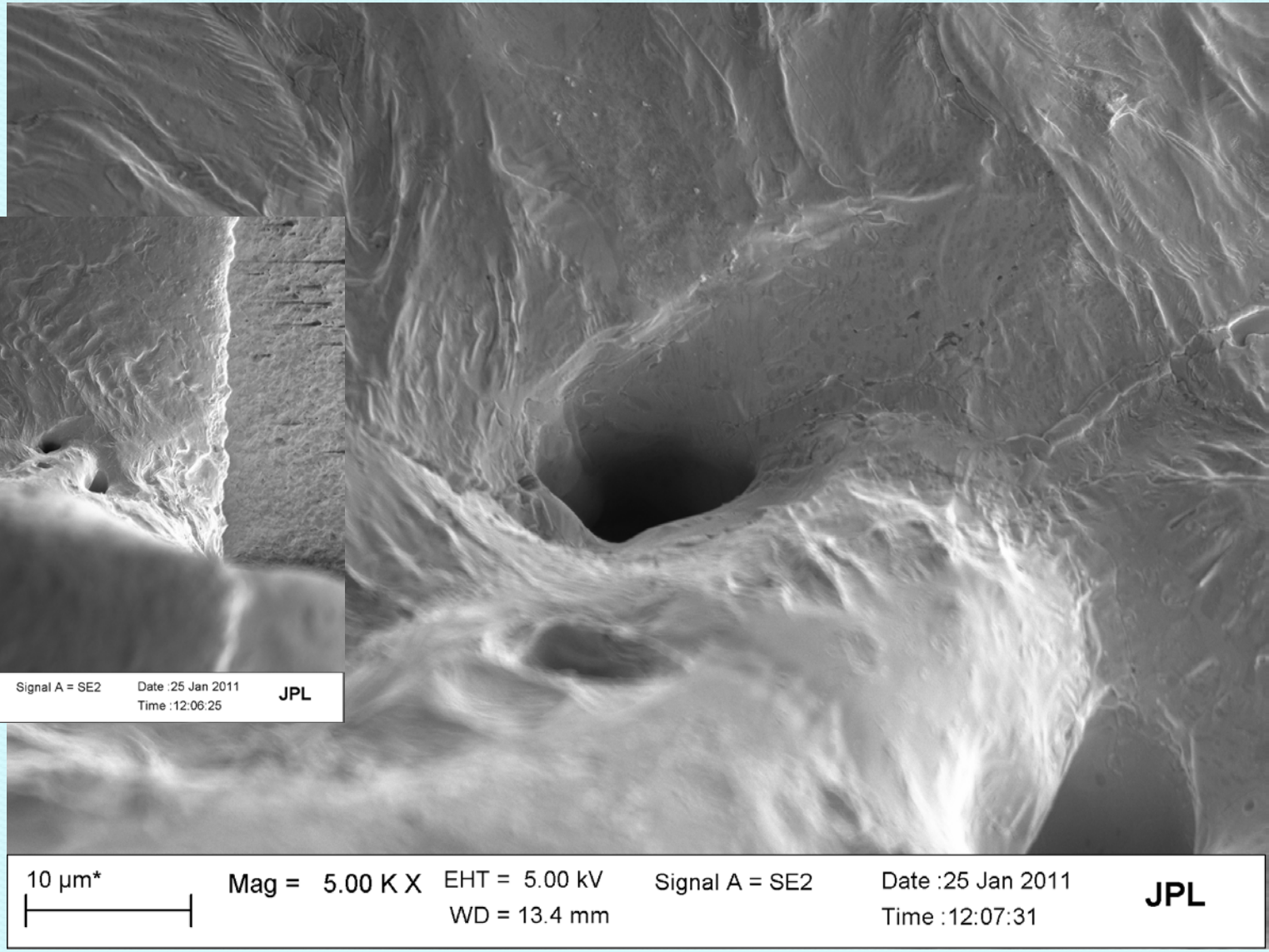
SEM of Capacitor Solder Joint





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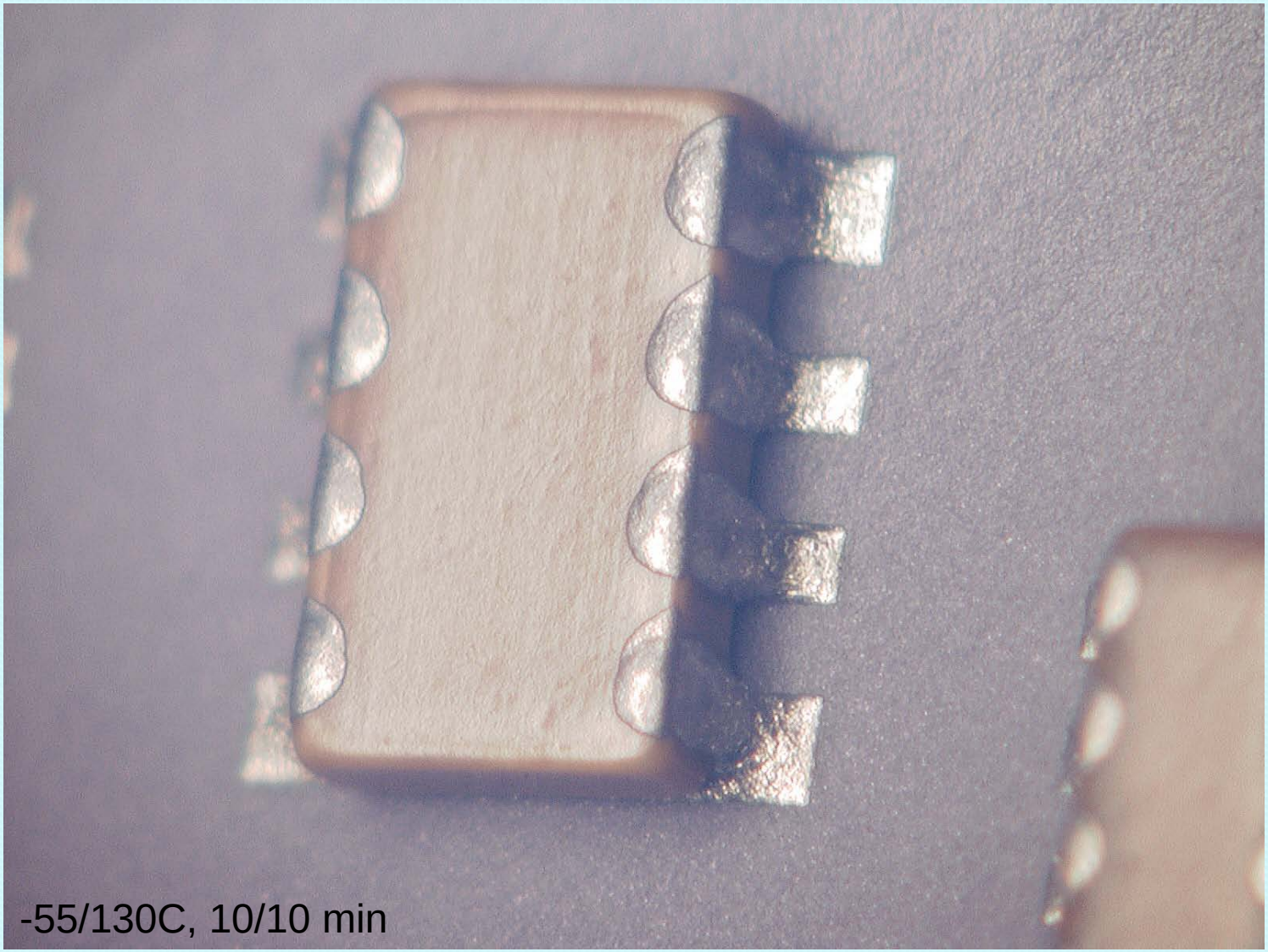
Capacitor Joint after 200TCs



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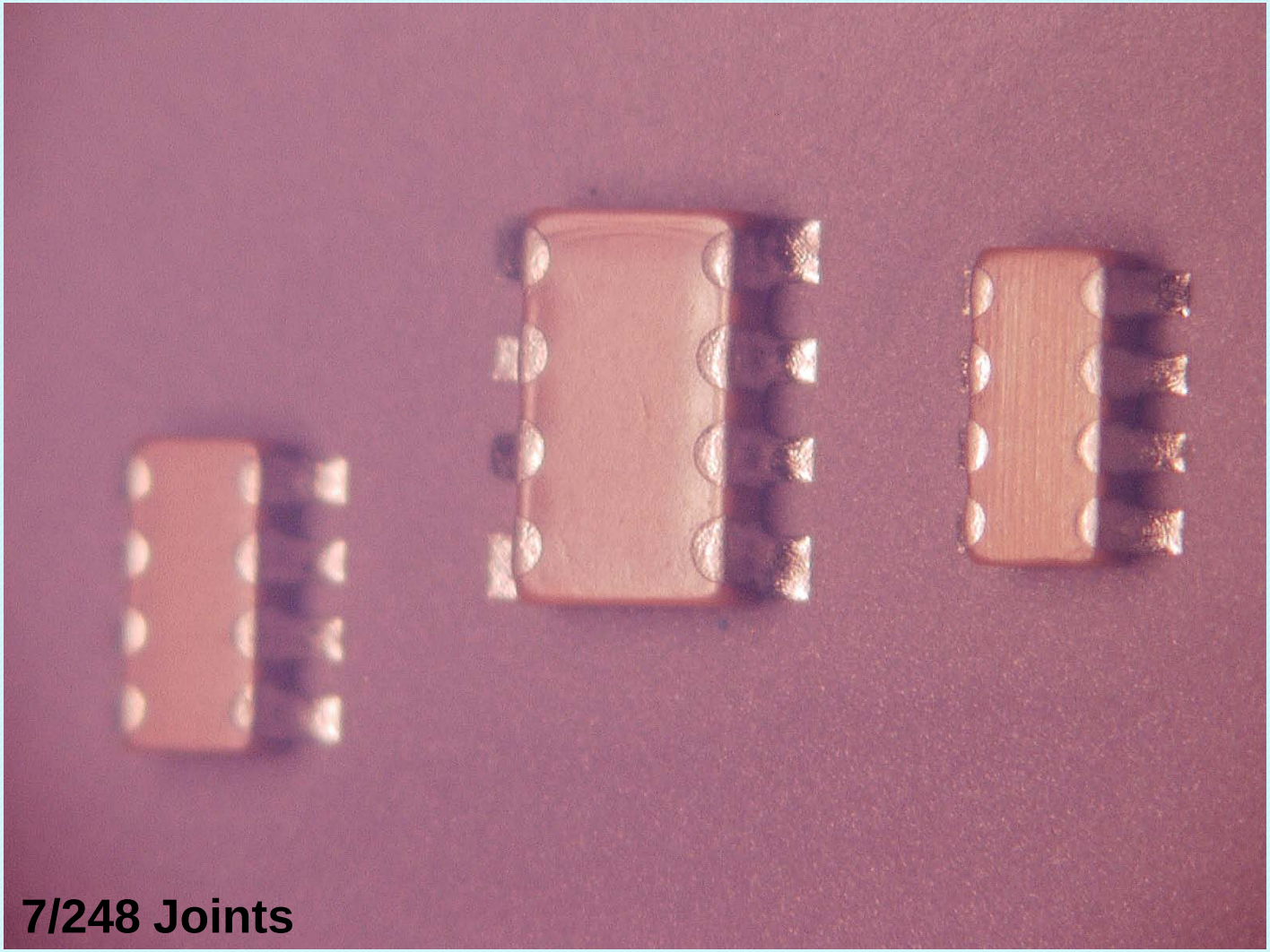
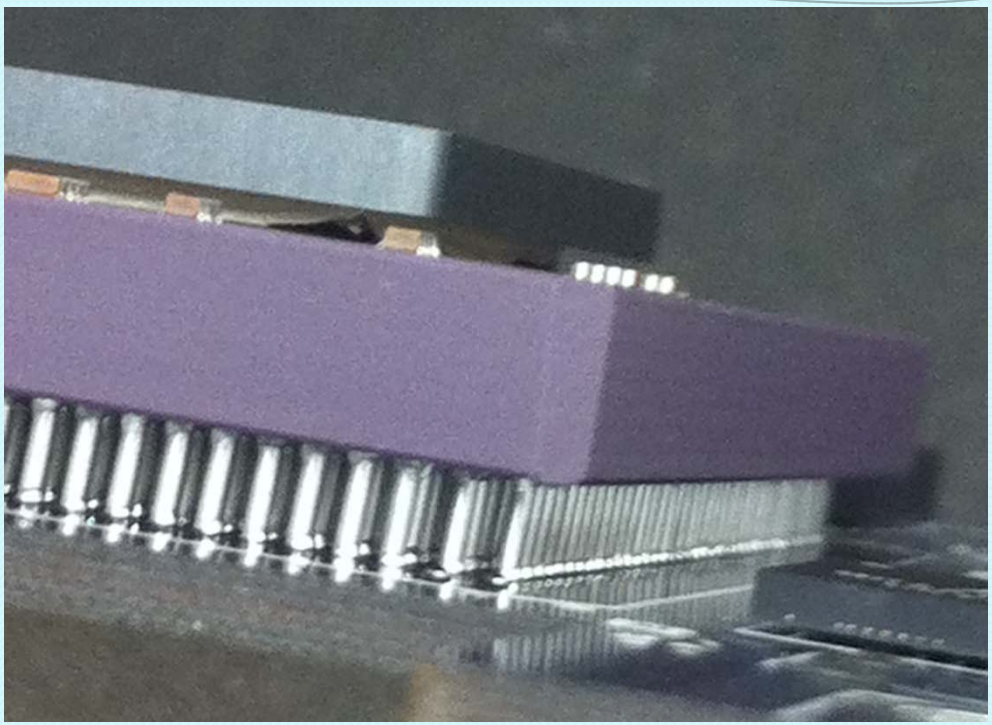
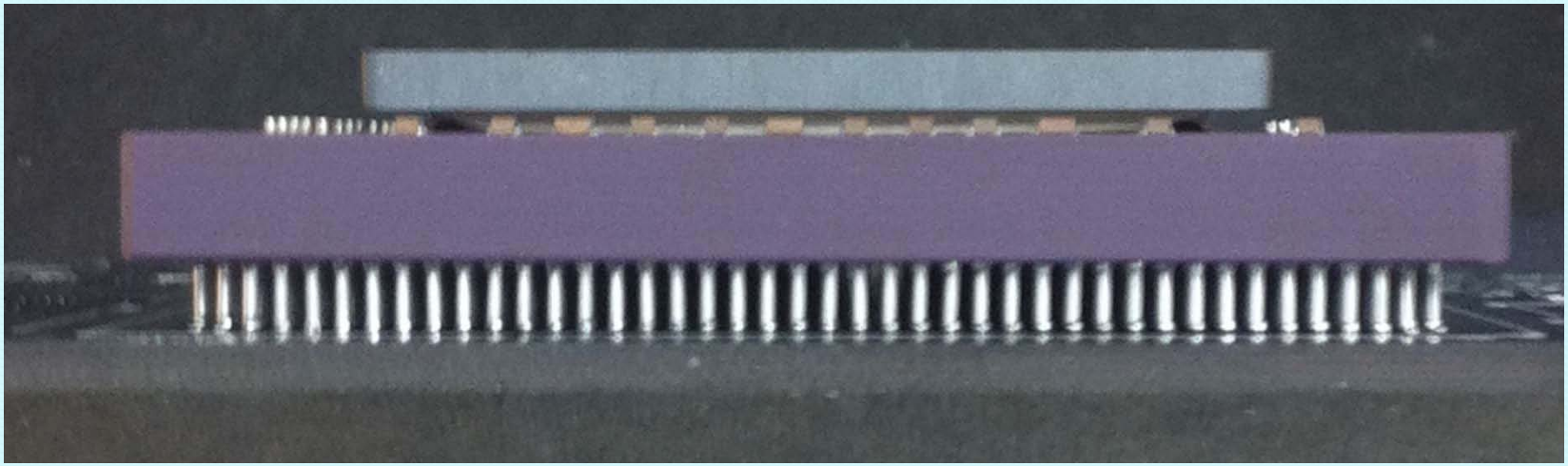
Capacitor Solder Joints

Received May 2011, 0805 (6)/0603 (25)



CGA Solder Joint Assembly





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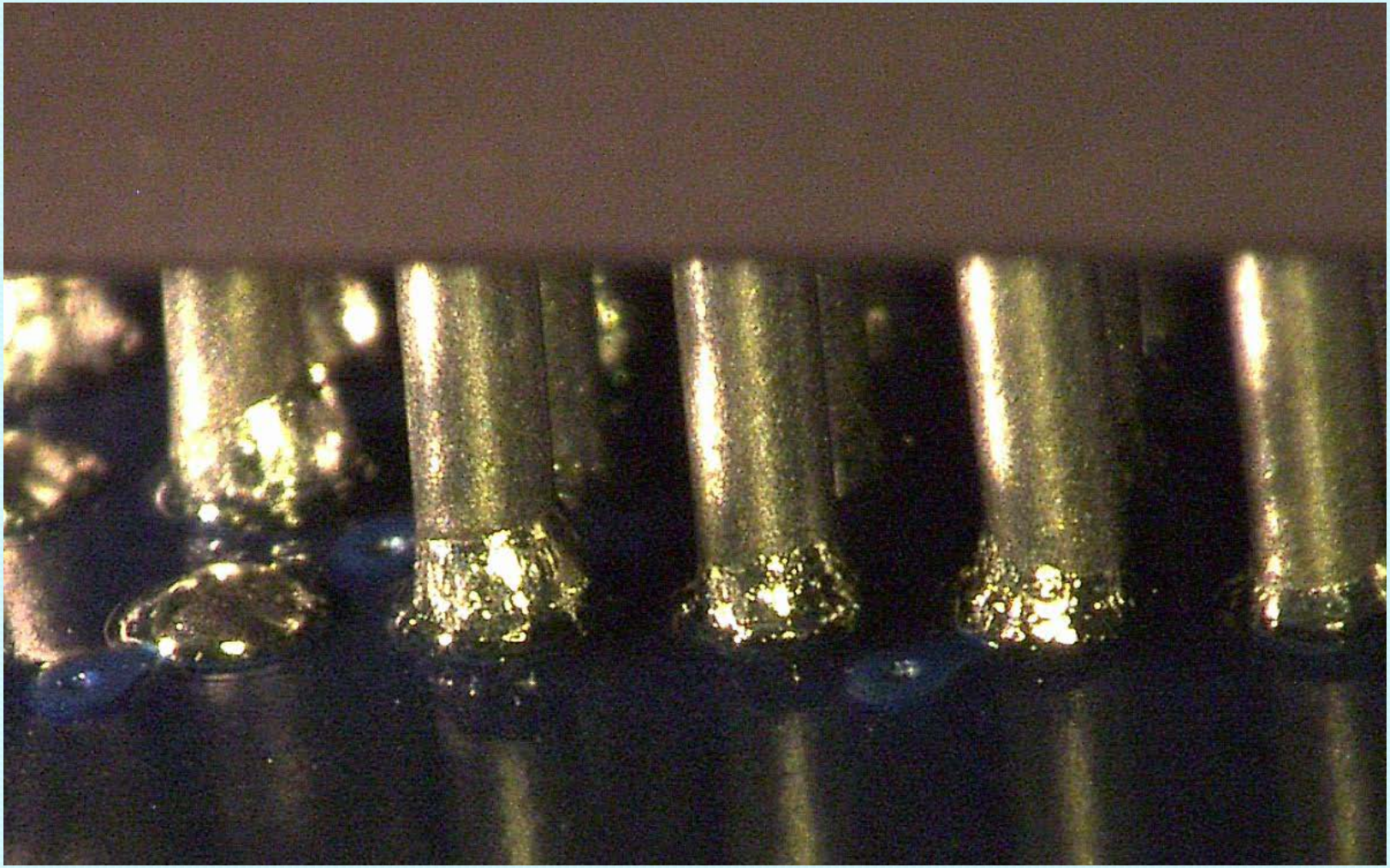
CGA Corner Solder Joints



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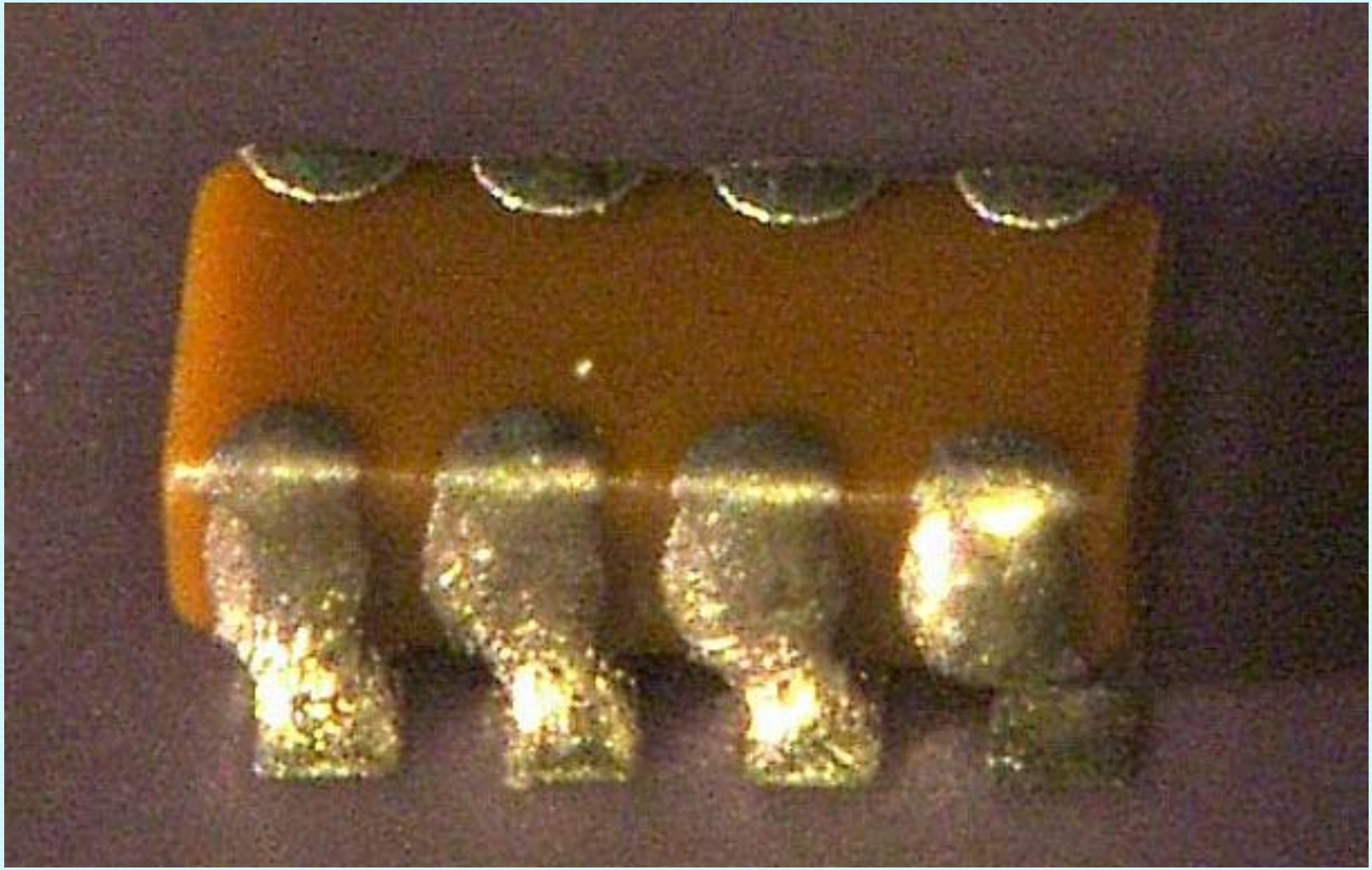
Failure of LCC Solder Joint



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Summary

- FCBGA
  - High assembly yield (Vapor/Rework Station)
  - No failure to 200 cycles of
    - -55/100°C , -55/125°C -125/125°C -55/100°C TS
      - Damage low by X-section/SEM
      - Low segregation of tin-lead and lead-free balls after cycles
  - Failed after only one drop with 485g level
- Advanced CGA
  - No failure of chip capacitor to 200 TCs
    - One solder joint separation
  - Successfuly Assembled onto PCB

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Future Activites

- FCBGA
  - Released NEPP Report
- Advanced LGA, CGA, HDI
  - Reliability testing of CGA assemblies
  - Complete column attachment on LGAs
    - Two column types & LGA, pull test verification
    - Assemble onto standard PCB
  - Design boards with HDI (microvia)
    - Assemble onto HDI board/optimize process
    - Reliability testing
- Active die, HDI, Reliability
  - Use lessons learned for efficient resource utilization
  - Release final report

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References

http://NEPP.nasa.gov