Introduction to HKUST/CAMP/EPACK Lab

Electronic Packaging Laboratory
Center for Advanced Microsystems Packaging
Hong Kong University of Science & Technology
Clear Water Bay, Kowloon, Hong Kong

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Center for Advanced Microsystems Packaging

Hong Kong University of Science and Technology

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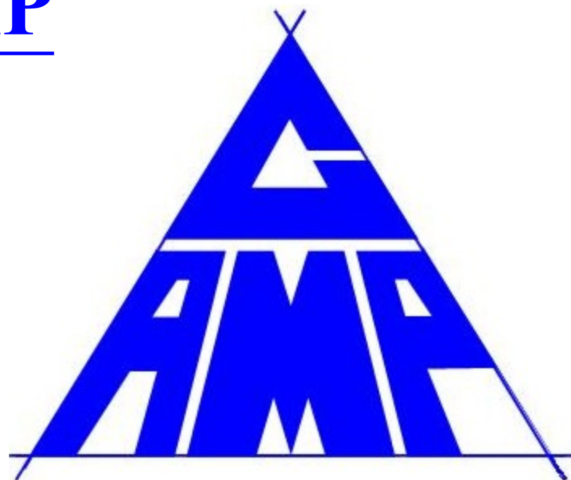
Center for Advanced Microsystems Packaging

EPACK Lab / CAMP



Center for Advanced Microsystems Packaging (CAMP)

Electronic Packaging Laboratory (EPACK Lab)

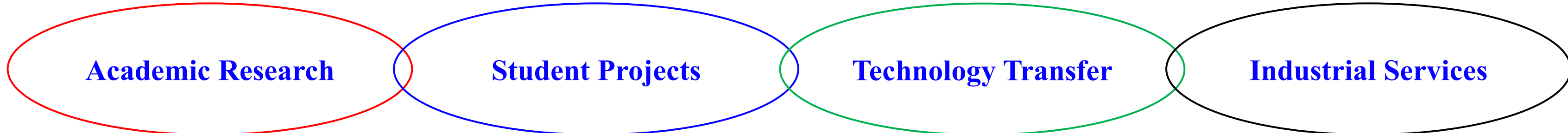
Prof. S. W. Ricky LEE
Director

Dr. Jeffery C. C. LO
Assistant Director

Justina KO
Clerk

Dr. Mian TAO
Senior Technical Officer

Professor: 1
PhD: 3
Post-graduate students: 4



R&D and Technical Services

Wafer Level Processes

a. Mask Design and Fabrication
b. Thin Film Deposition
c. Photolithography
d. Dry/Wet Etching
e. Plating (TSV, UBM, Solder, etc)
f. Wafer dicing

Chip/Package Level Processes

a. Die Bonding (Adhesive, Eutectic)
b. Wire Bonding (Au, Al, Cu)
c. Flip Chip Bonding (Thermo-compression, Thermo-sonic)
d. Underfill, Molding & Encapsulation

Board Level Processes

a. Substrate and PCB Layout
b. SMT
c. Rework

Simulation

a. Mechanical
b. Thermal
c. Thermo-mechanical
d. Optical

Reliability Assessment

a. Thermal Cycling
b. HAST
c. Moisture Sensitivity Level
d. Microtesting (Die Shear, Ball Pull/Shear, Wire Pull/Shear)
e. Bending (Monotonic, Cycling)
f. Drop Test

Failure Analysis

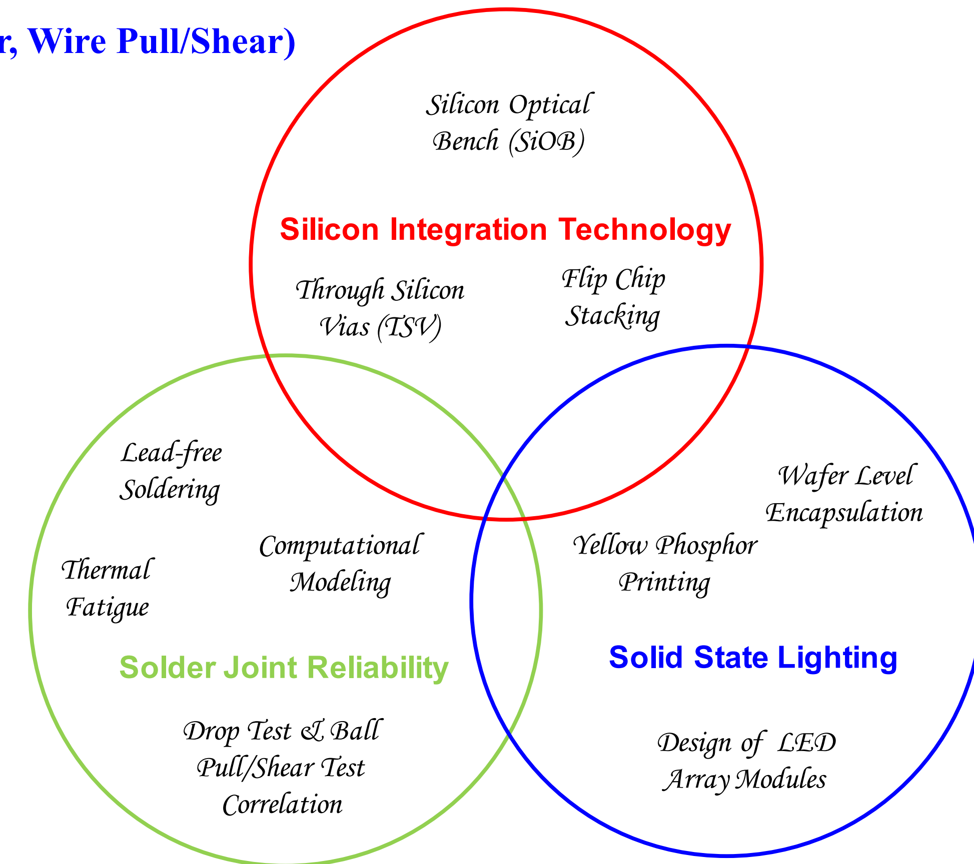
a. X-Ray & C-SAM
b. Cross-section Inspection
c. SEM/EDX Inspection

Material Characterizations and Inspection

a. DSC, DMA, TMA, TGA
b. Thermal Conductivity Measurement
c. All UTM Related Testing
d. Roughness, Warpage Measurement

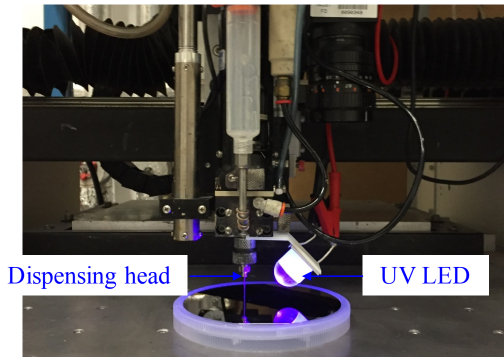
Optical/Thermal Characterization

a. Integrating Sphere
b. Goniophotometer
c. Fluorescence Spectrometer
d. Thermal Transient Tester

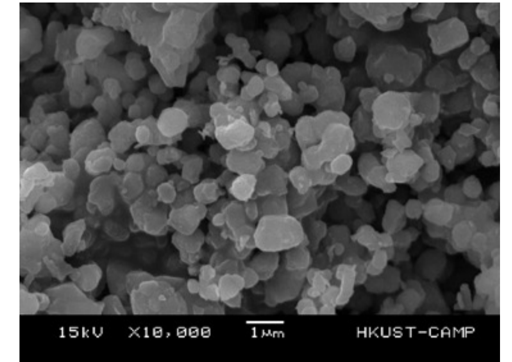


Research Projects

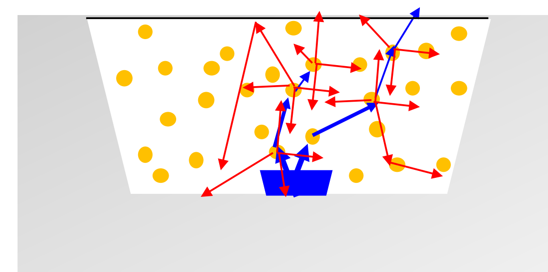
- **Additive Manufacturing for Advanced Microsystems Packaging**
  - Polymer core copper pillar
  - Redistribution Layers
- **LED Packaging**
  - LED System-in-Package
  - White Light LED SPD Prediction
  - Thermal Management for High Power LEDs
  - UV LED Packaging
- **Solder Joint Reliability**
  - Correlation of Joint and Board Level Reliability
- **Implantable Medical Device Packaging**

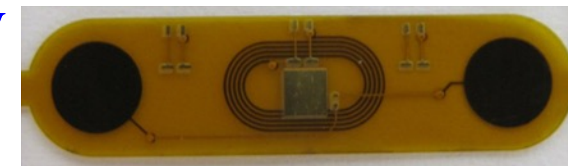


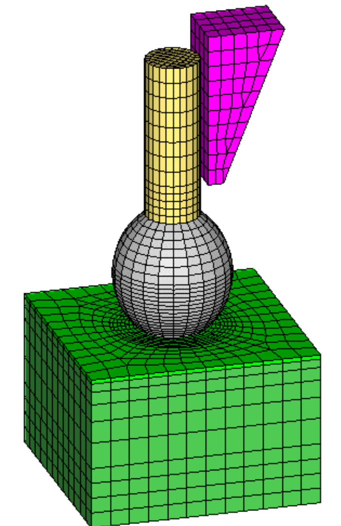
Instant Epoxy Curing System



High Thermal Conductivity Underfill


LED SPD Prediction


Implantable Medical Device

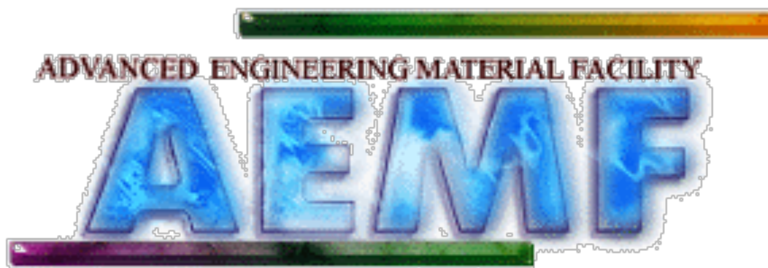

Pin Shear Test Simulation

Partners @ HKUST

Materials Characterization & Preparation Facility (MCPF)
www.mcpf.ust.hk

Nano Fabrication Facilities (NFF)
www.nff.ust.hk

HKUST LED-FPD Tech. R&D Center at Foshan
www.fsldctr.org



www.aemf.ust.hk

www.dmsf.ust.hk

Semiconductor Product Analysis and Design Enhancement (SPADE) Center
www.spade.ust.hk

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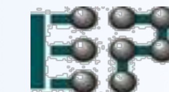
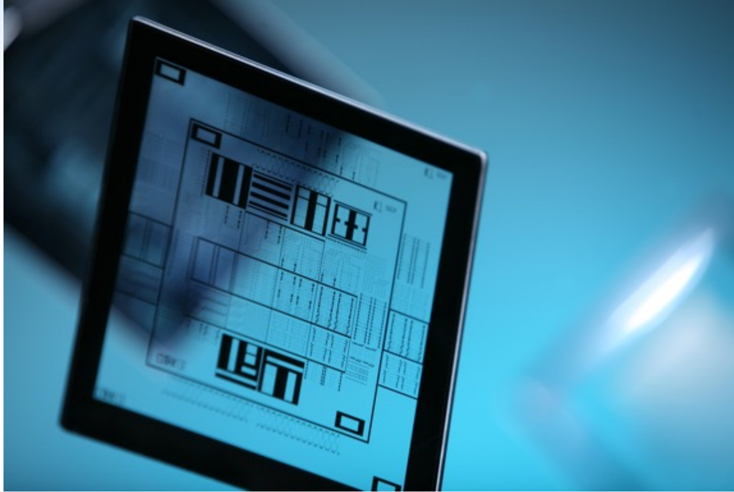


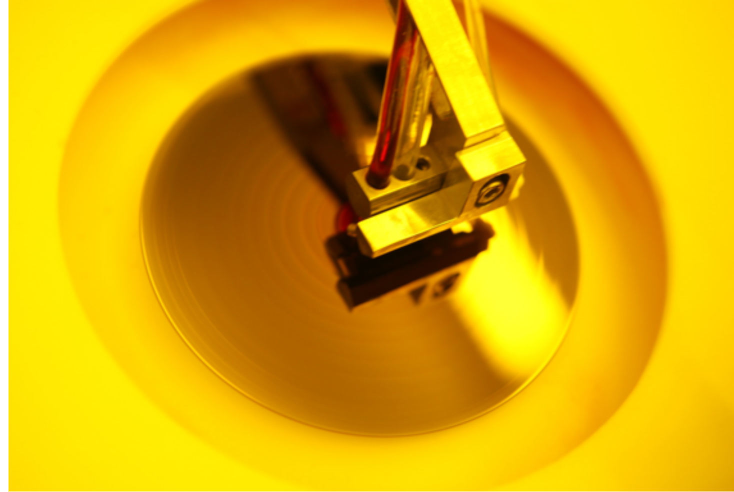
Funding Sources and Industrial Partners

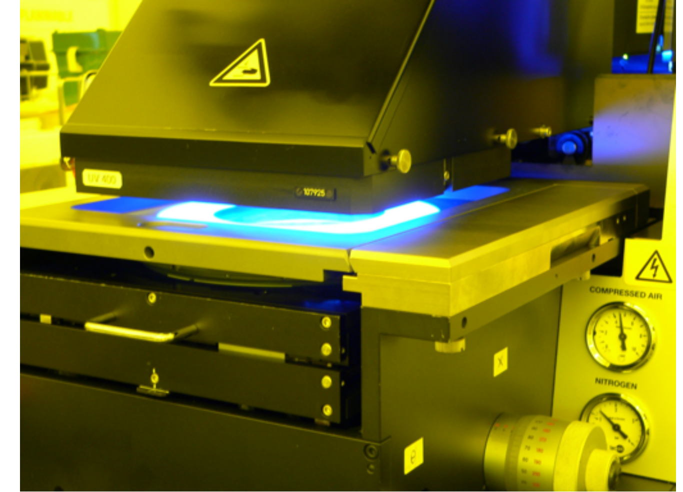
- Research Grant Council (RGC)
- Innovation and Technology Fund (ITF)
  - Midstream and downstream R&D projects
  - Collaborate with industrial partners
- Industrial Services
- Collaborative R&D Projects
- Engineering-Industrial Consortium (EIC) Membership

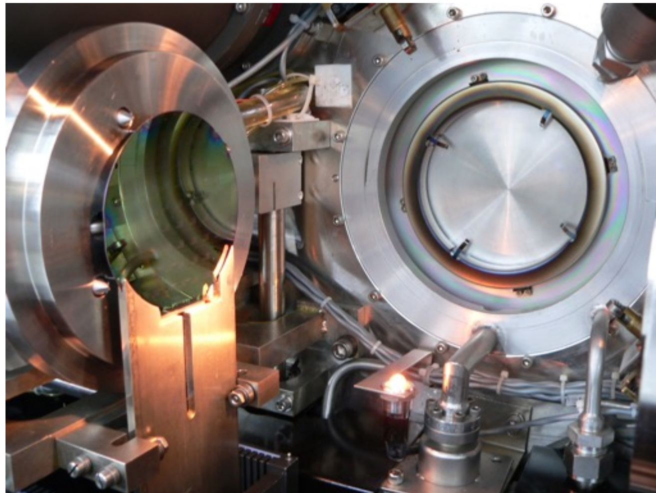
Photolithography

Source: NFF @ HKUST

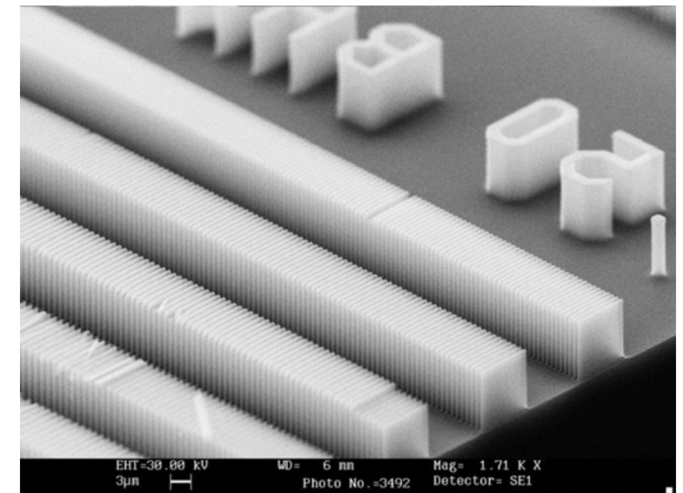

Mask Making


Photoresist Coating (Spin/Spray Coating)


Contact Aligner

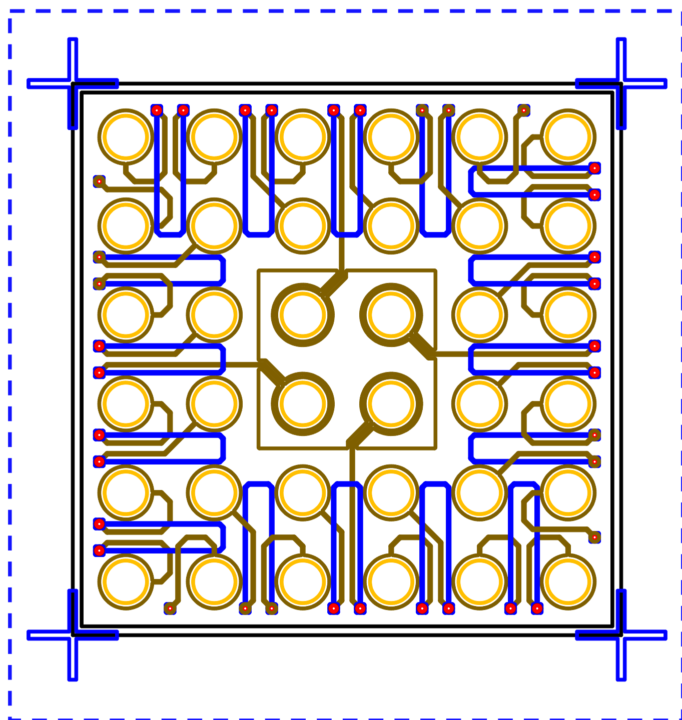

Thin Film Deposition

Wet Process

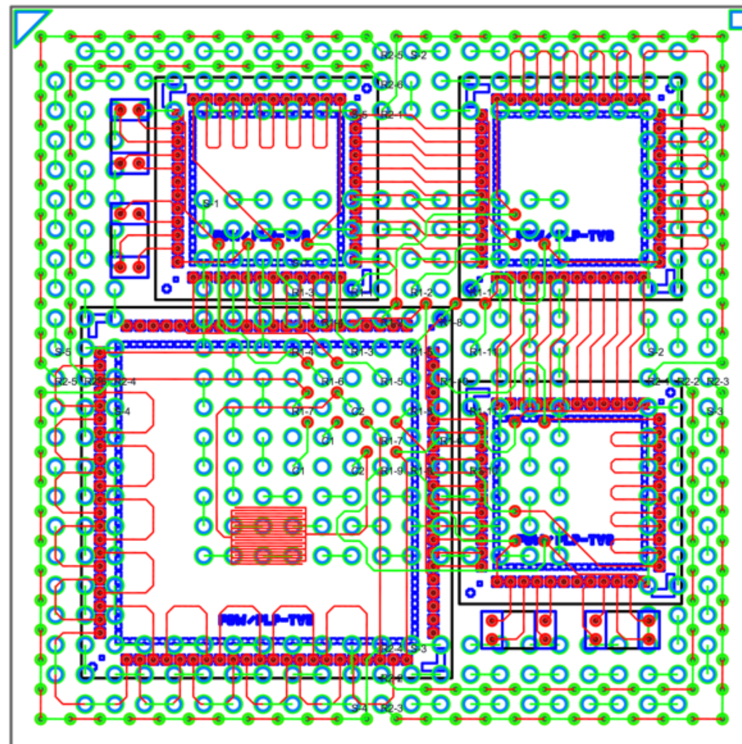


Dry Etching

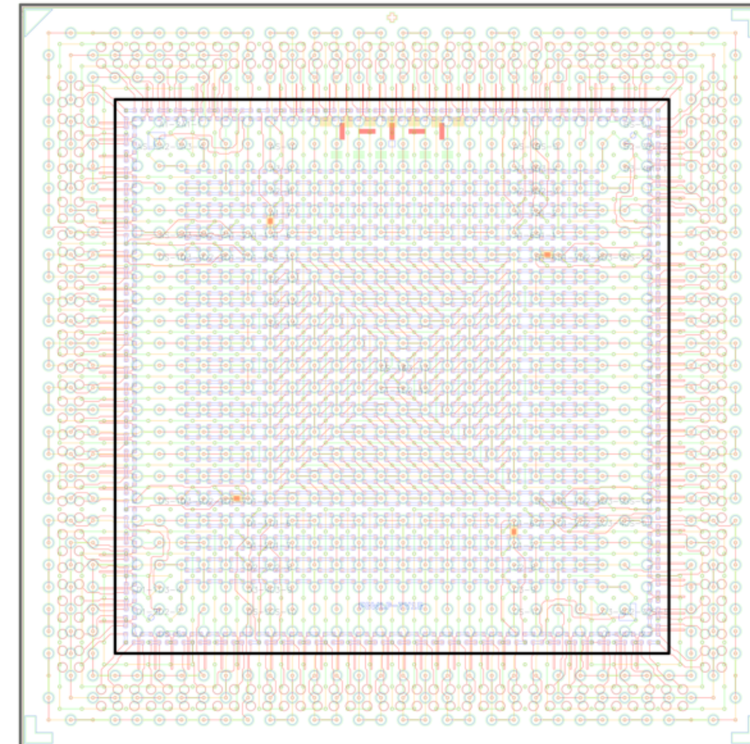
Wafer Level Process (Mask Design)



Fan-in WLCSP
1 RDL Layer

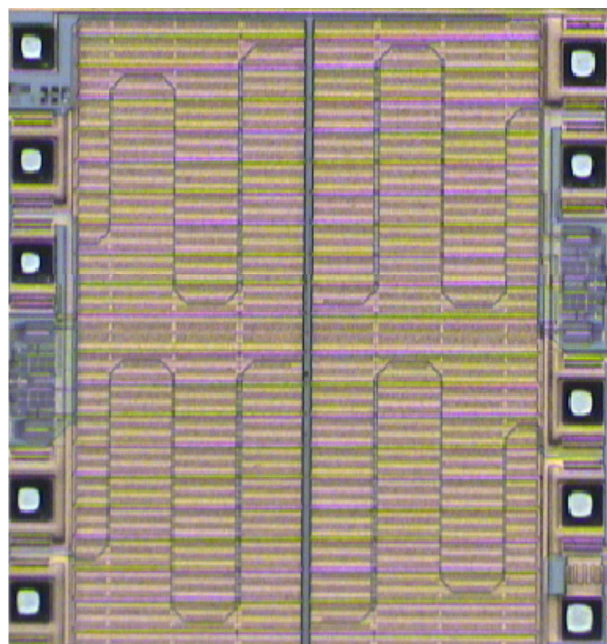


Fan-out WLP (SiP)
2 RDL Layers

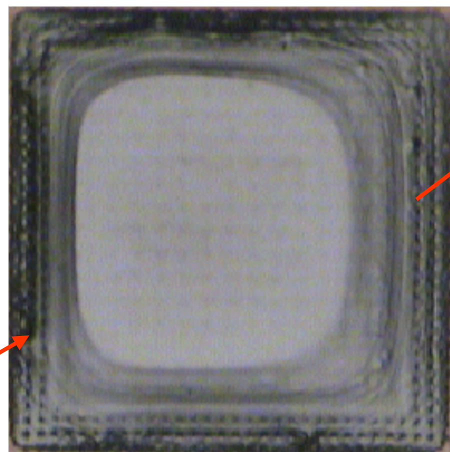


Fan-out WLP
3 RDL Layers

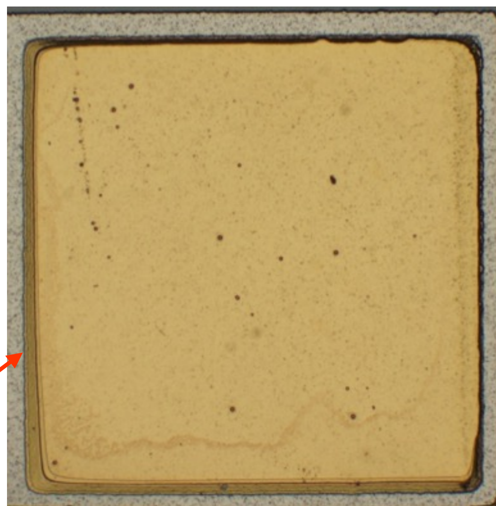
Electro-/Electroless Plating



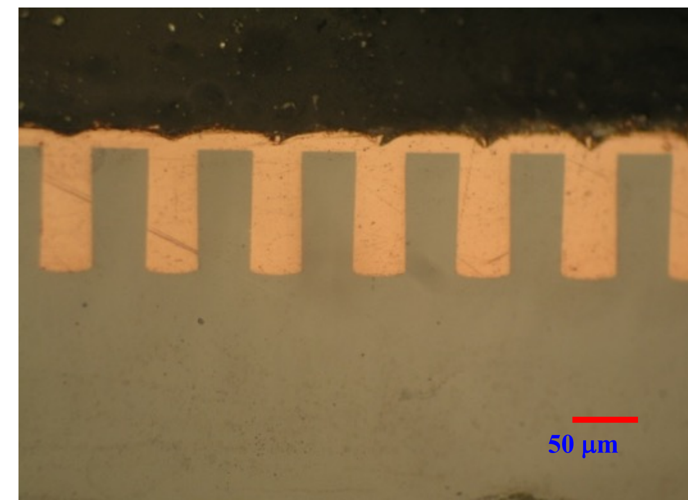
IC with Al Pad

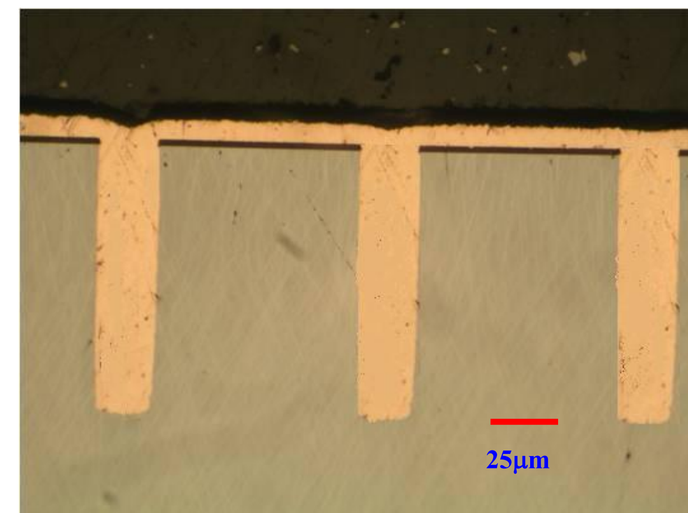


Electroless Nickel Plating



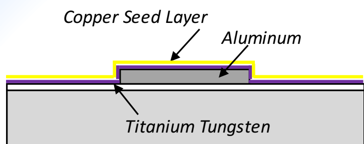
Electroless Gold Plating



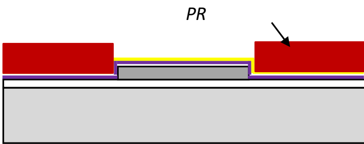


TSV Plating

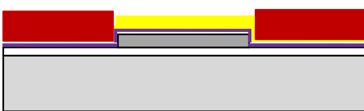
Wafer Level Bumping



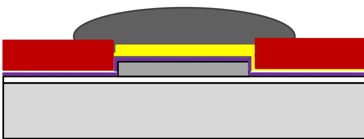
Deposition of Adhesion and Seed Layer



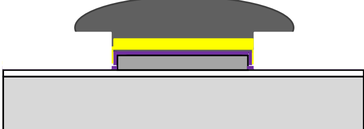
Thick PR Mask Patterning



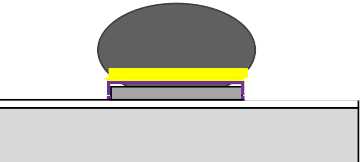
Electro-Copper Plating



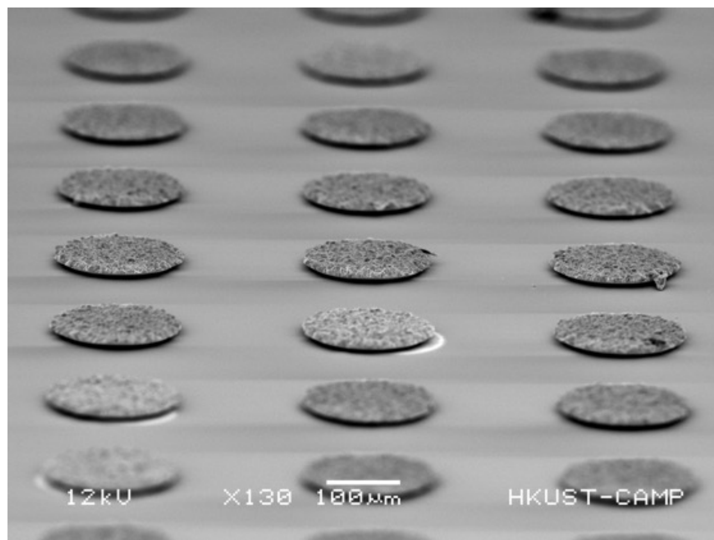
Solder Plating

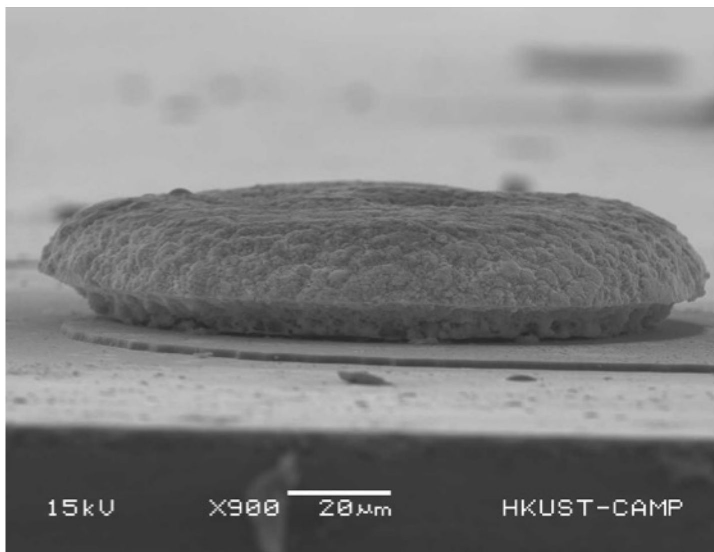


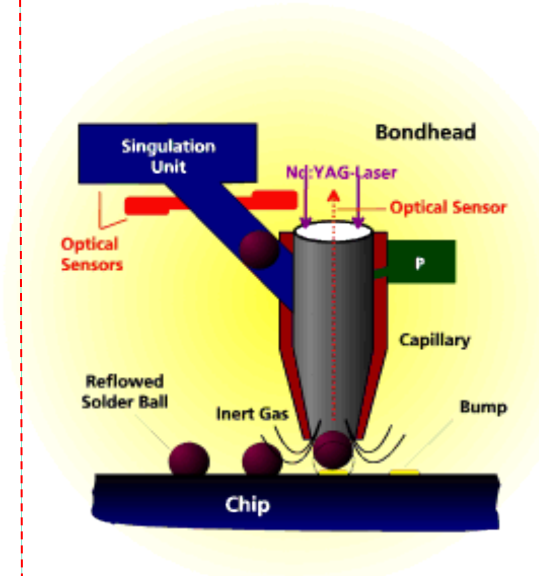
PR Stripping and Seed Layer Etching

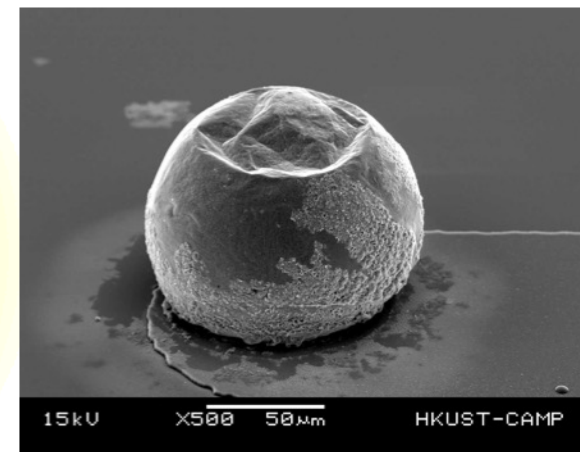


Reflow



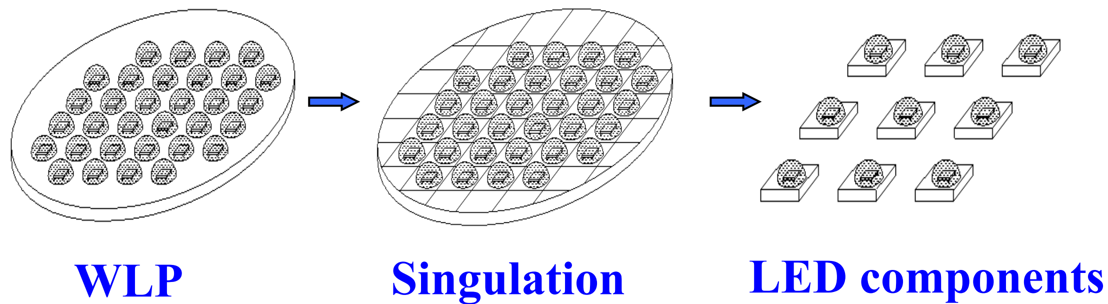


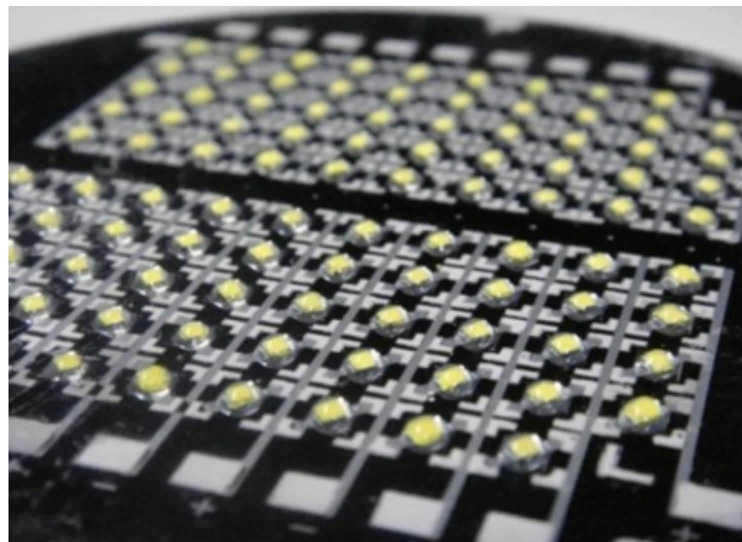


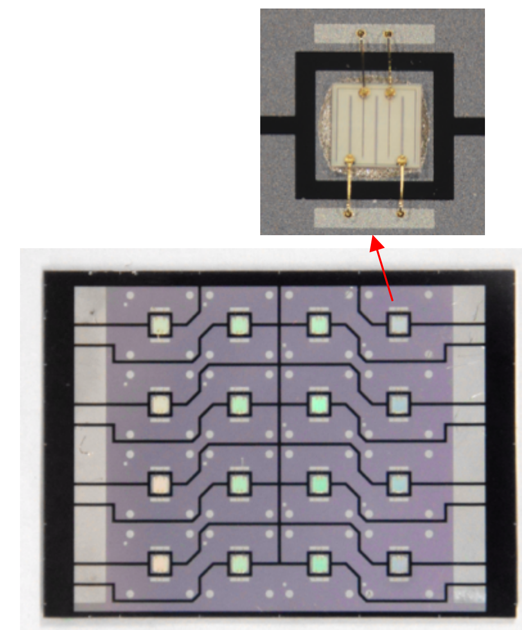


Laser Solder Ball Bumping

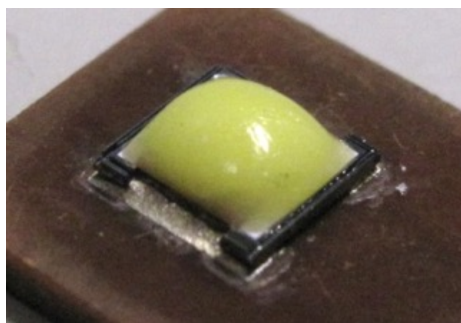
LED Wafer Level Packaging



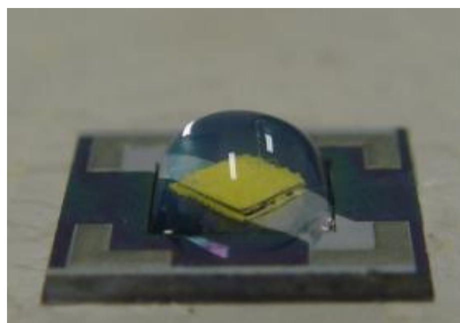




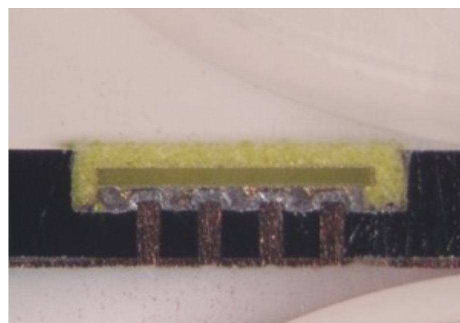
Silicon Carrier for LED WLP



WLP with Dispersed Phosphor

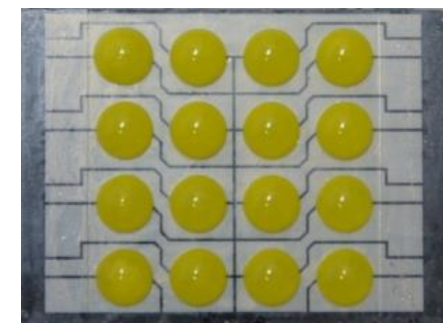


WLP with Conformal Phosphor by Mask Printing



WLP with Conformal Phosphor by Cavity Printing

WLP with Remote Phosphor Film

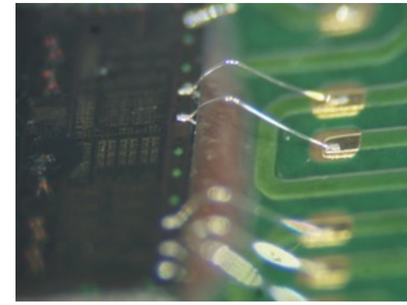


WLP with Remote Phosphor Cap

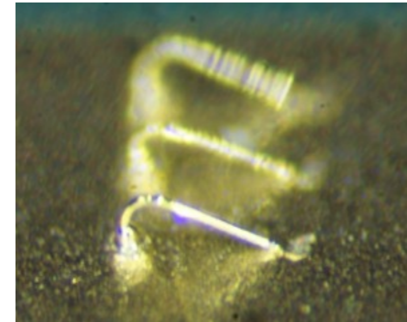
Wire Bonding

4KE Convertibility Semi-Automatic Wire Bonder

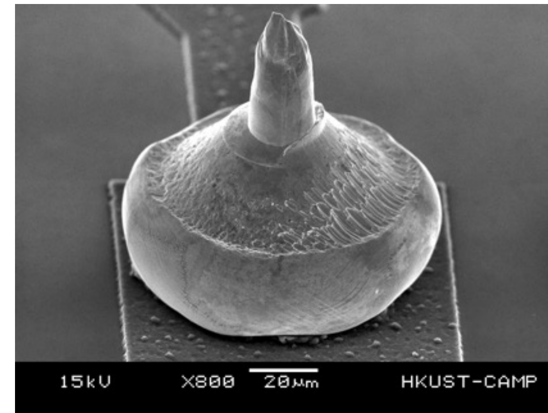
- Bond area:
  - Work holder: 6” x 4” (150mm x 100mm), max 200℃
  - Adjustable height: 0.625” (15.9mm)
  - Max bond span: 0.349” (8.9mm)
- Bond parameters:
  - Bond force: 10g-250g (low/high programmable)
  - Bond time: 0ms-999ms
  - Programmable: 40 device with 30 wire types, up to 5 bonds per wire, individual power, time and loop control data per wire type
  - Ultrasonics: 63kHz, 2.5W (4W optional)
- Wire capability:
  - Au/Al: 0.7 to 3mil (18 to 75μm)
  - Ribbon: 0.5x2mil to 1x10mil (12.5x50μm to 25x250μm)
  - Cu ball bonding: 0.7 to 1.5mil (18 to 38μm)



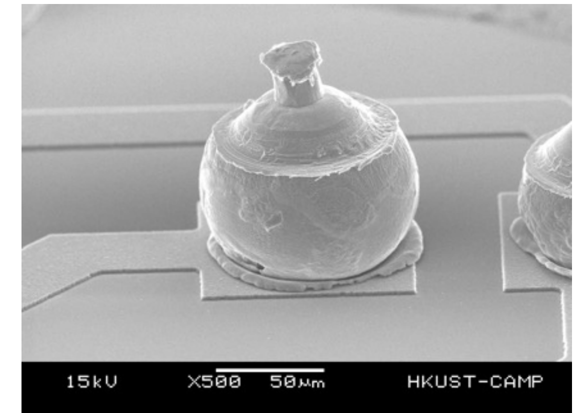
Al Wire



Gold Wire

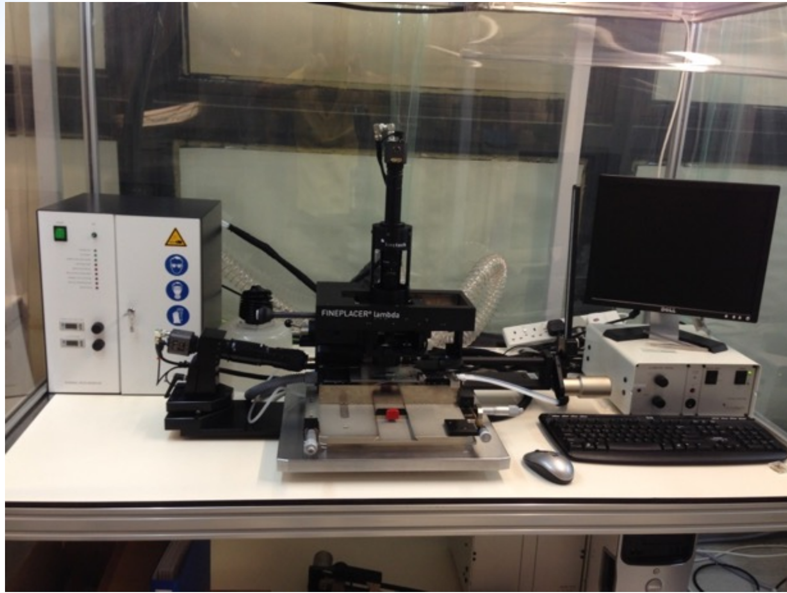


Gold Stud



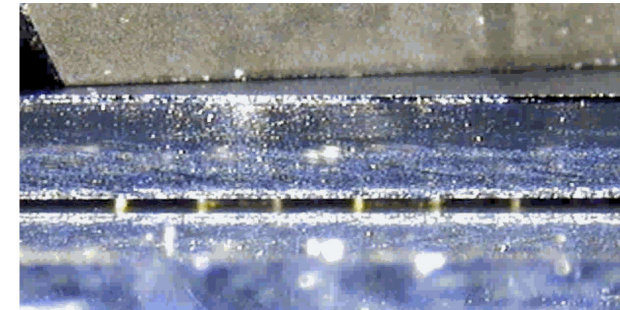
Copper Stud

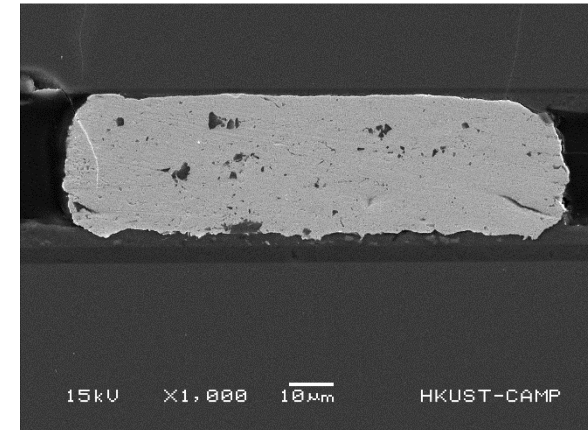
Flip Chip Bonding



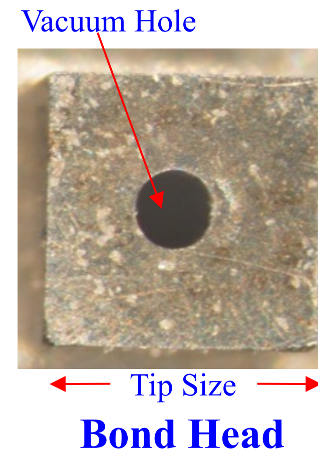
Fine Tech Flip Chip Bonder

- Bonding Accuracy: 0.5 µm
- Max. Die/Package Size: 16 mm (Pick-n-Place Only)
- Substrate Size
  - 50 x 50 mm (Thermal Compression)
  - 180 x 108 mm (Pick-n-Place only)
- Bonding Environment
  - Nitrogen / Formic Acid
- Bonding Mechanism
  - Thermal compression (Bond Force 0.1 – 200 N)
  - Reflow (RT-400°C, Heating Rate: 20°C/s)
  - Thermosonic





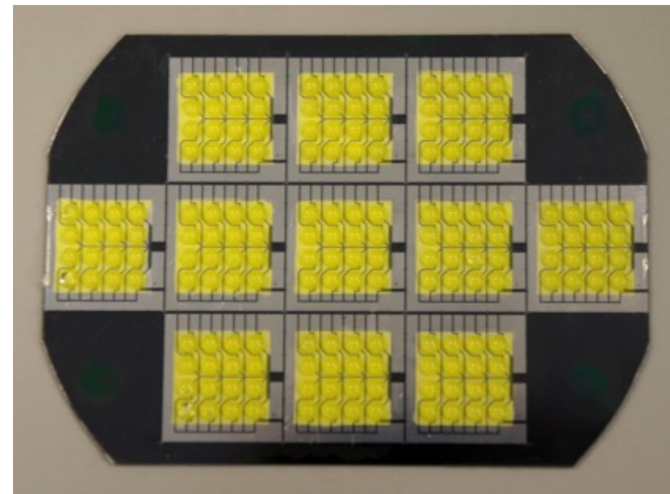
Bonding Mechanism	Thermal Compression					Thermosonic		
	1	2	3	4	5	1	2	3
Tip Size, mm	0.5	1	3	5	10	0.5	1	3
Vacuum Hole Size, mm (Min. Die Size)	0.15	0.3	0.6	2	4	0.12	0.3	0.65



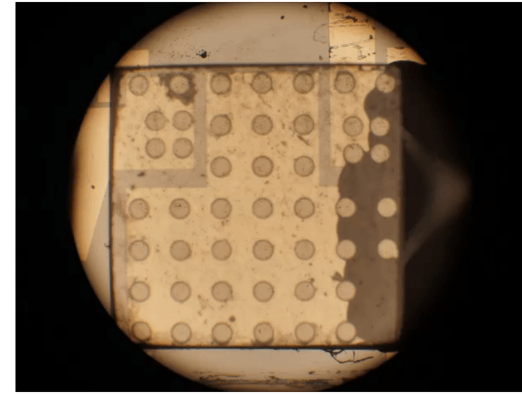
Bond Head

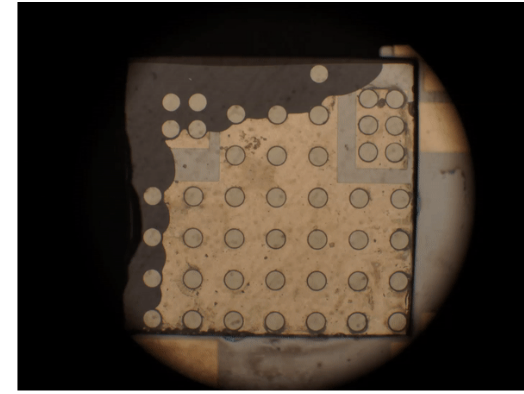
Molding and Underfill Encapsulation

Transfer Molding

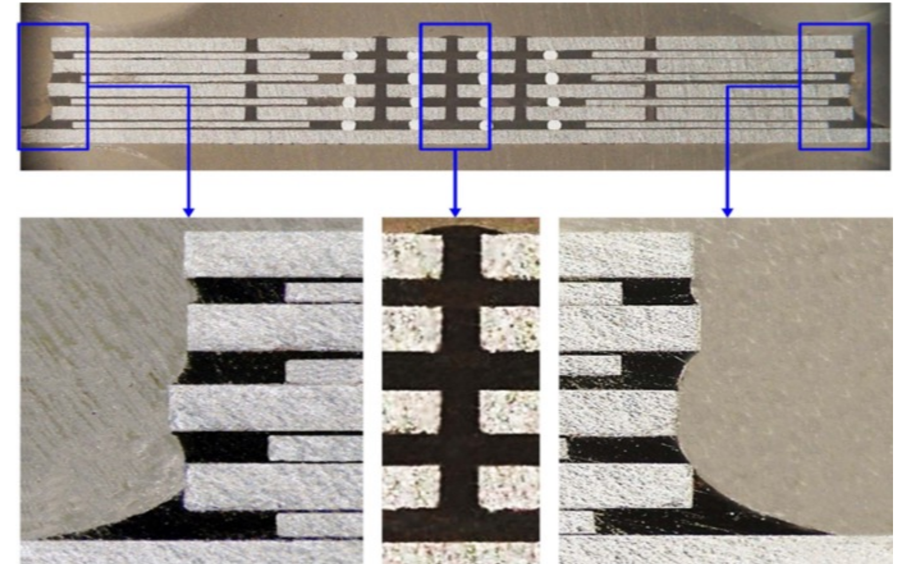


Compression Molding for LED WLP



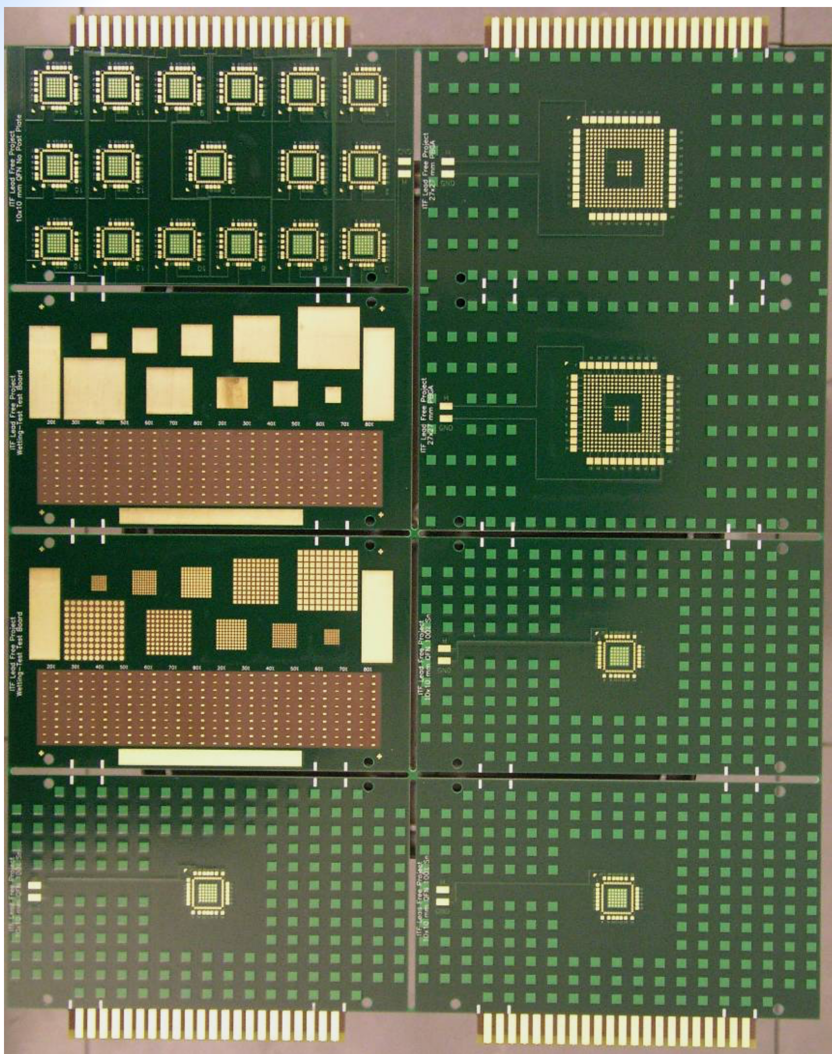


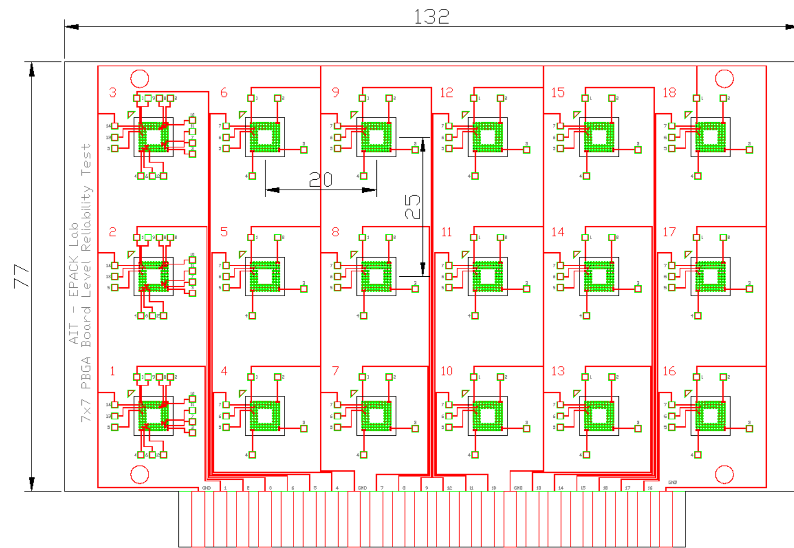
Underfill Dispensing

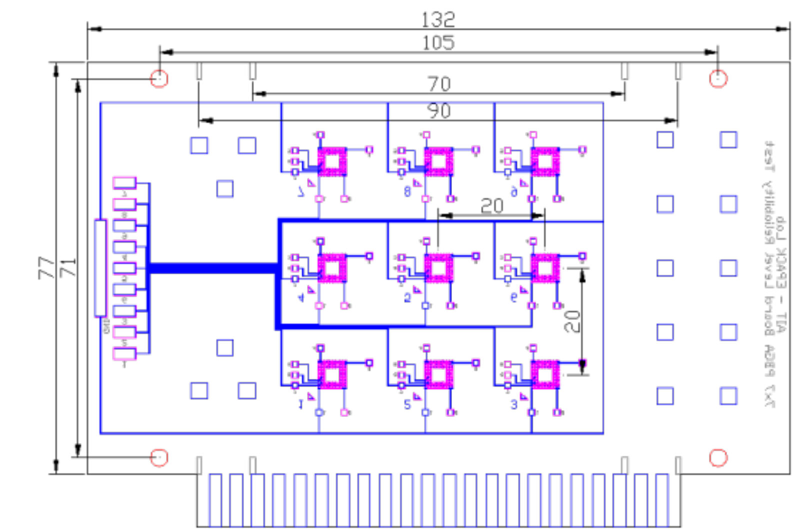


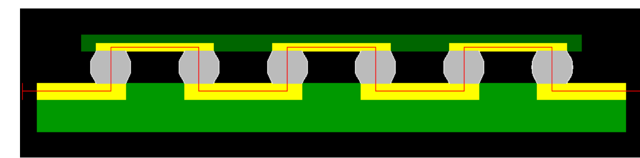
Undefill Encapsulation for 3D Package

PCB Layout Design for Reliability Tests

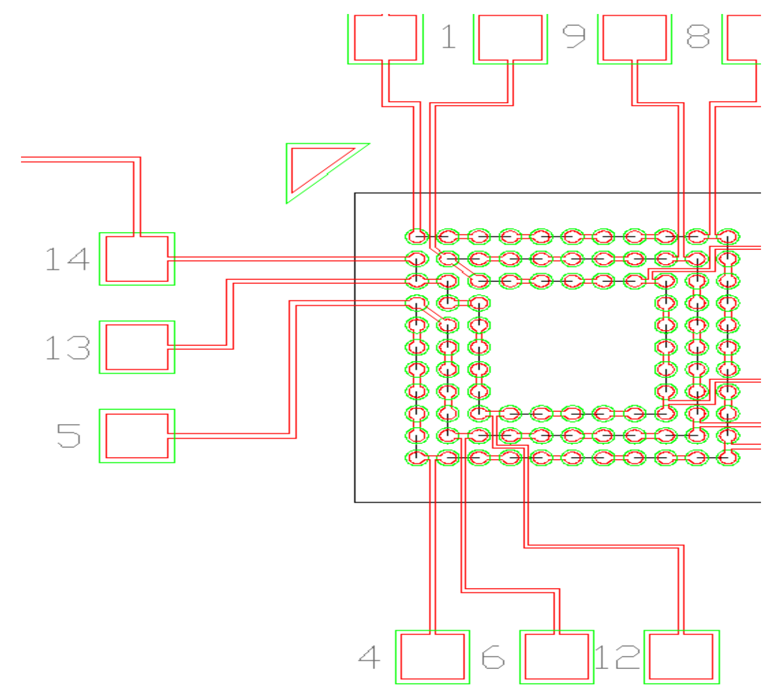








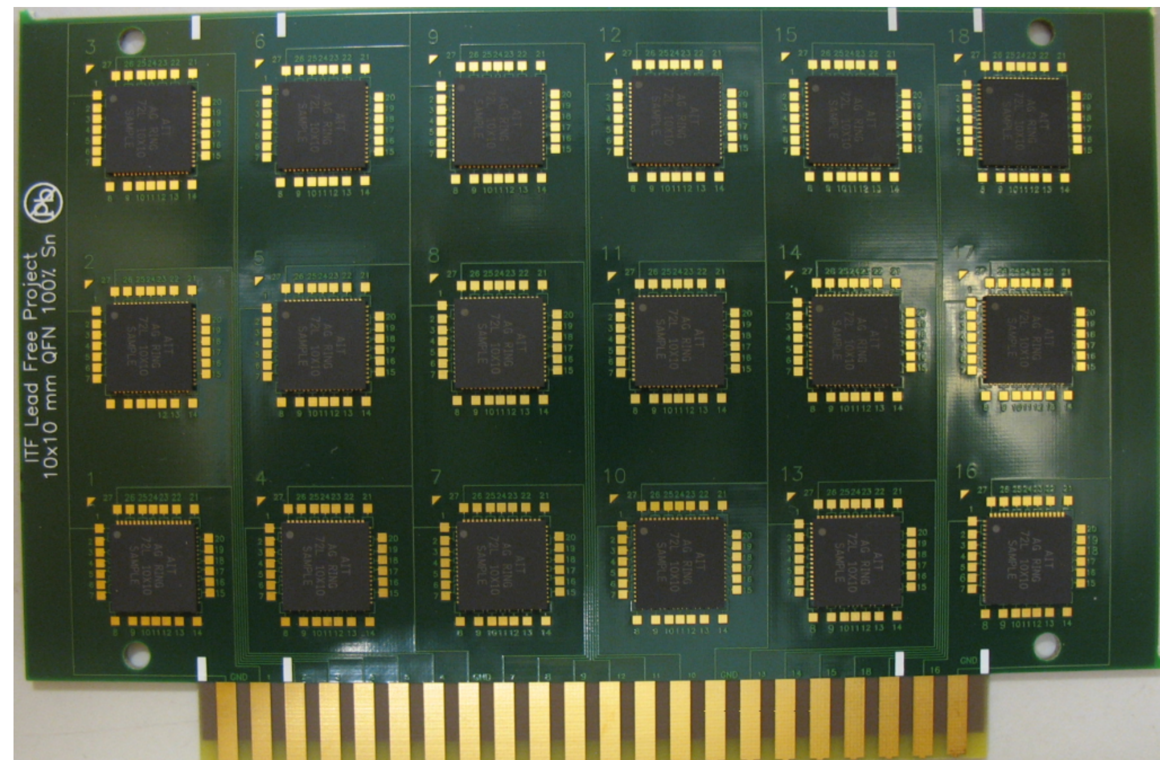
Mechanism of Daisy Chain

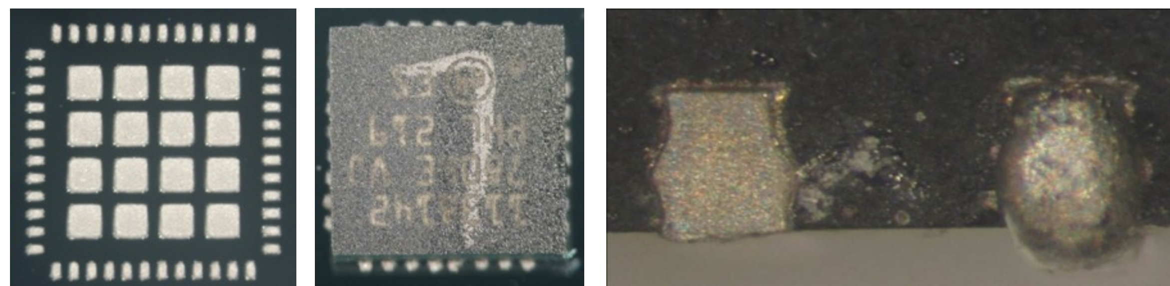


Daisy Chain Design with Local Probing

SMT and Solderablity Test

8 Zones Reflow Oven



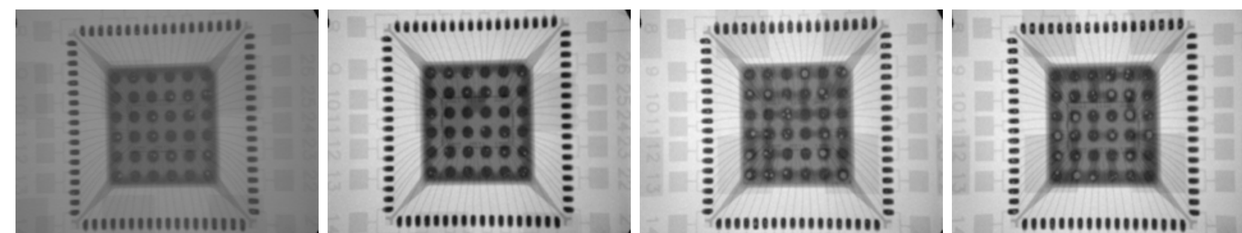


Paste Printing

Pick-n-Place

Wettability Inspection

Solderability Test



SAC305

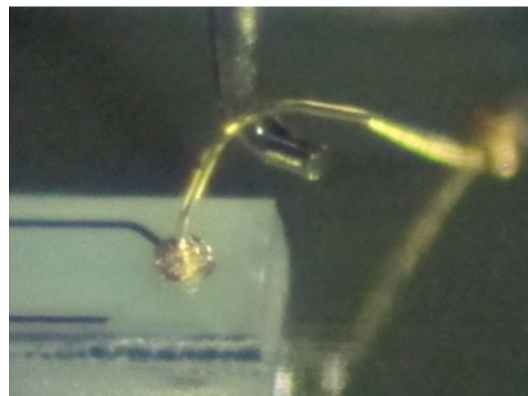
SAC387

SCN

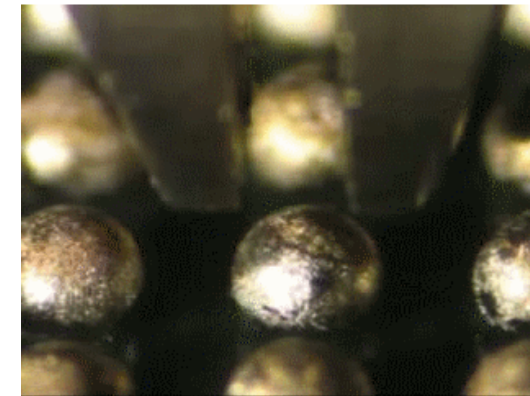
SACC

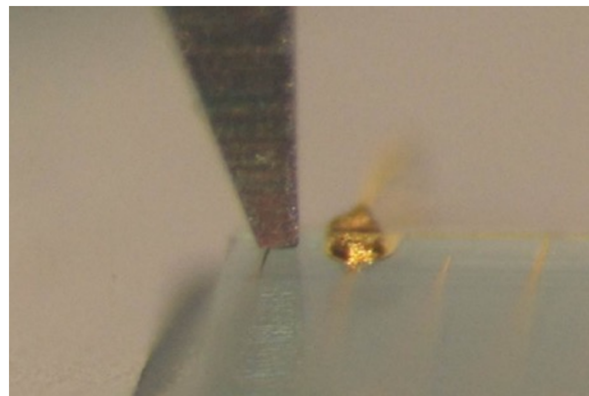
Package Level Reliability Tests

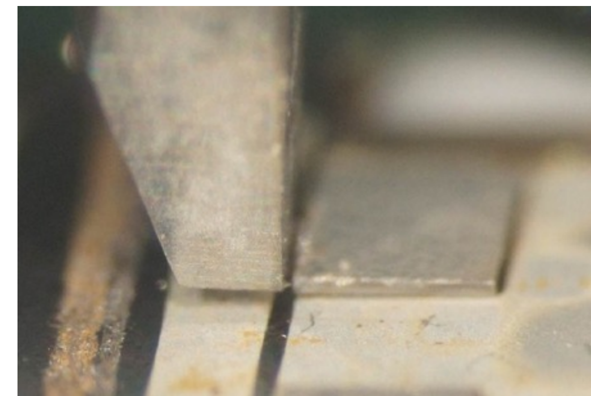
DAGE 4000 Plus Microtester


Wire Pull

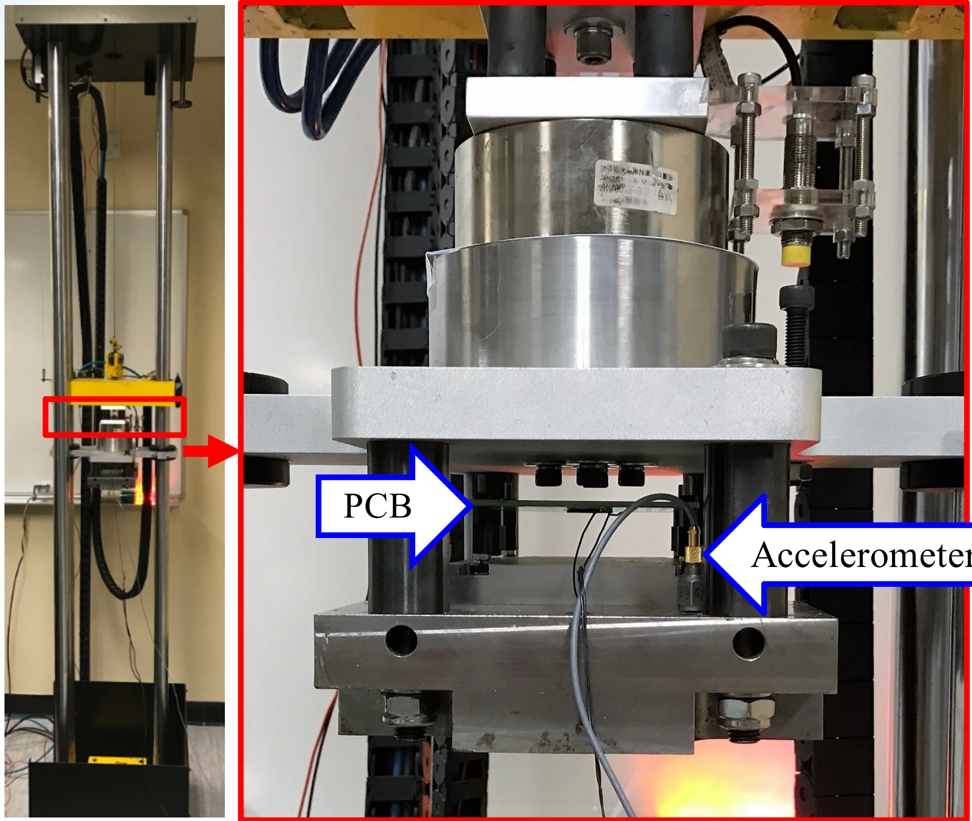
Button Shear

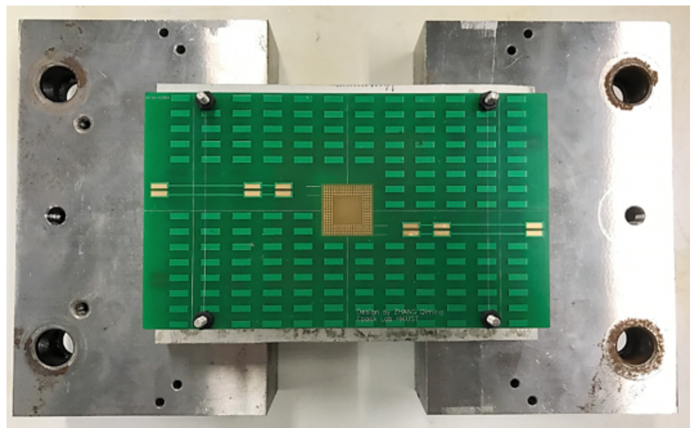

Solder Ball Pull

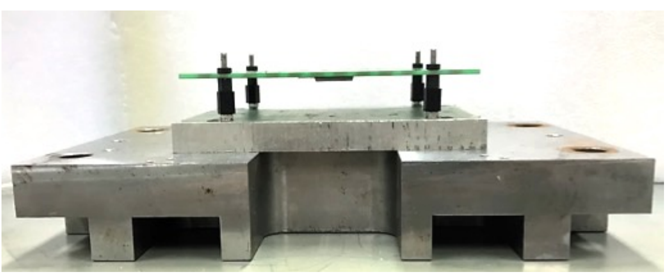

Bump Shear

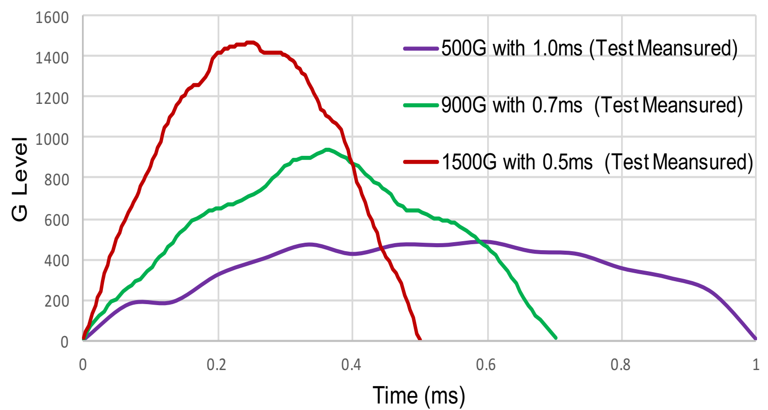

Die Shear

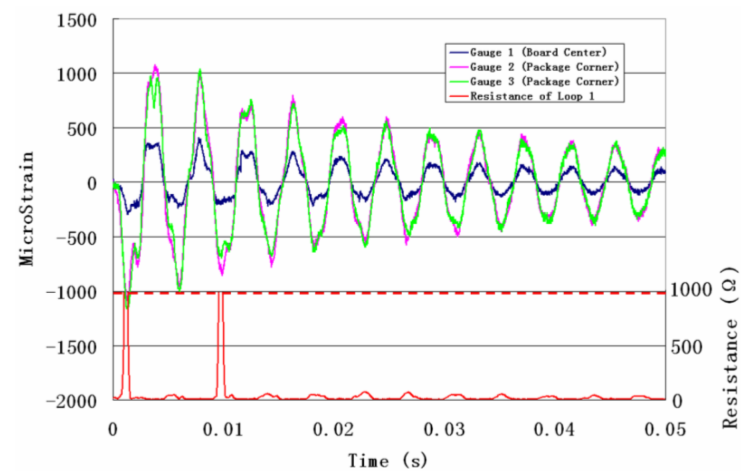
Board Level Reliability Test

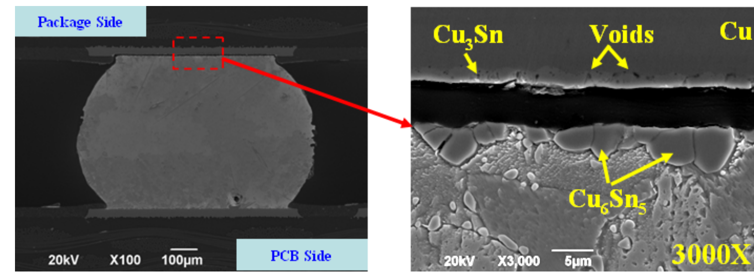












Board Level Reliability Test (Bending)

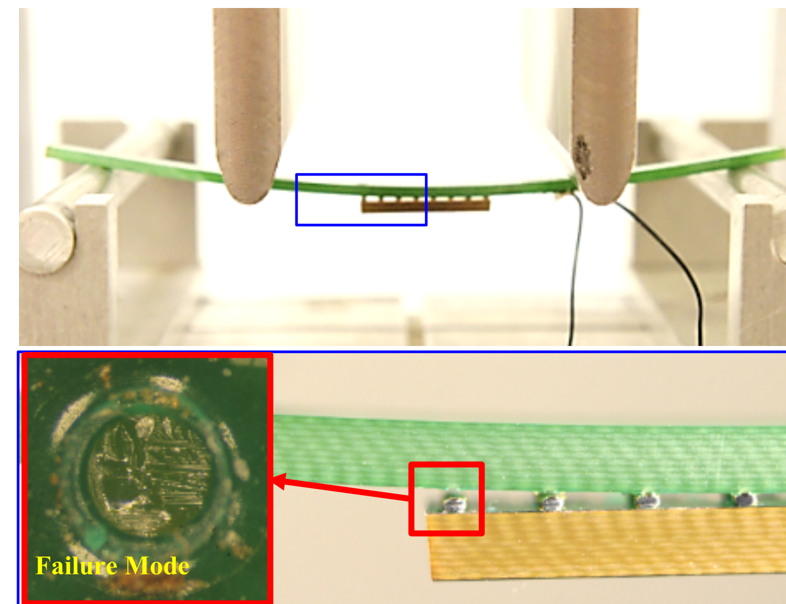
8 Bit Oscilloscope
to record displacement and force

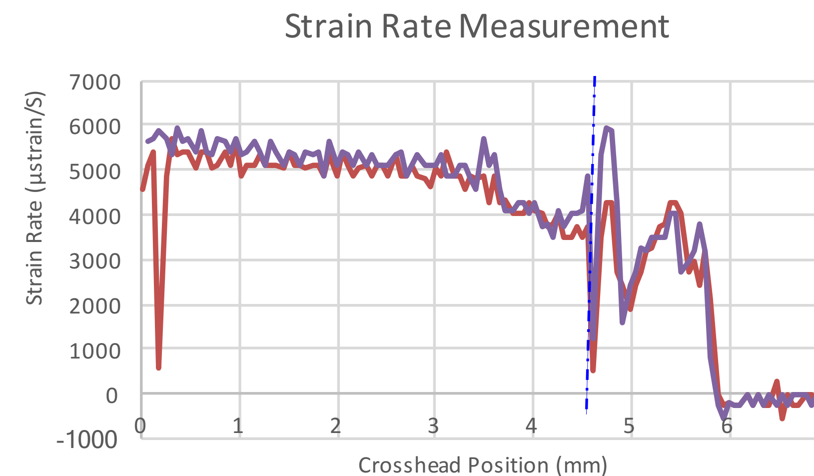
Strain Meter

12 Bit Oscilloscope
to record strain/strain rate

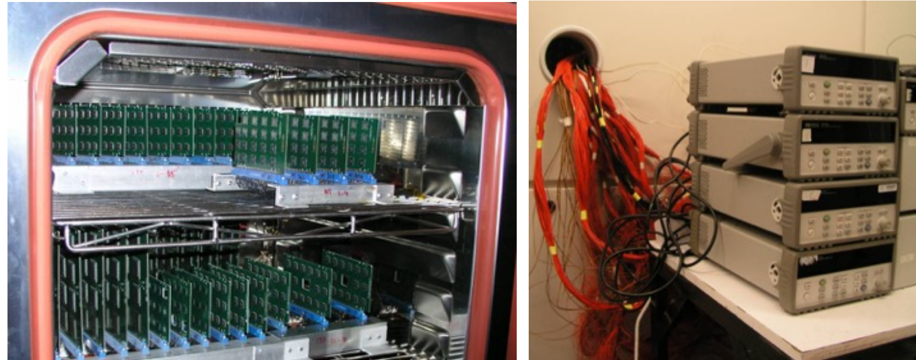
Universal Test Machine

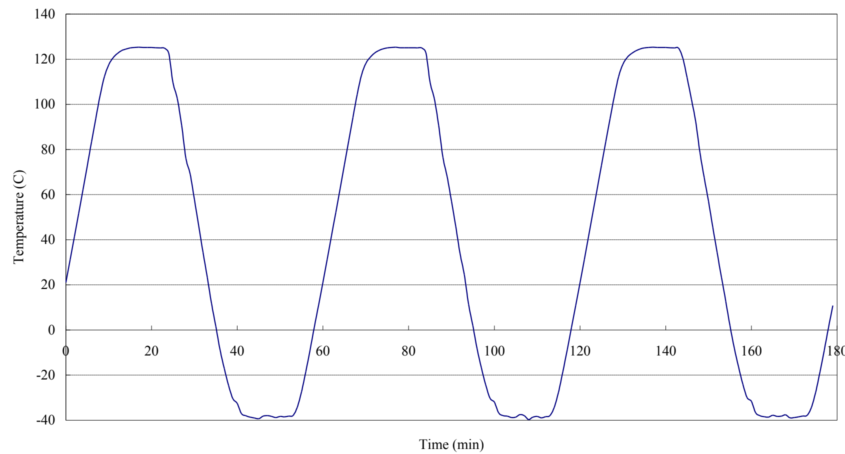
Bending Sample

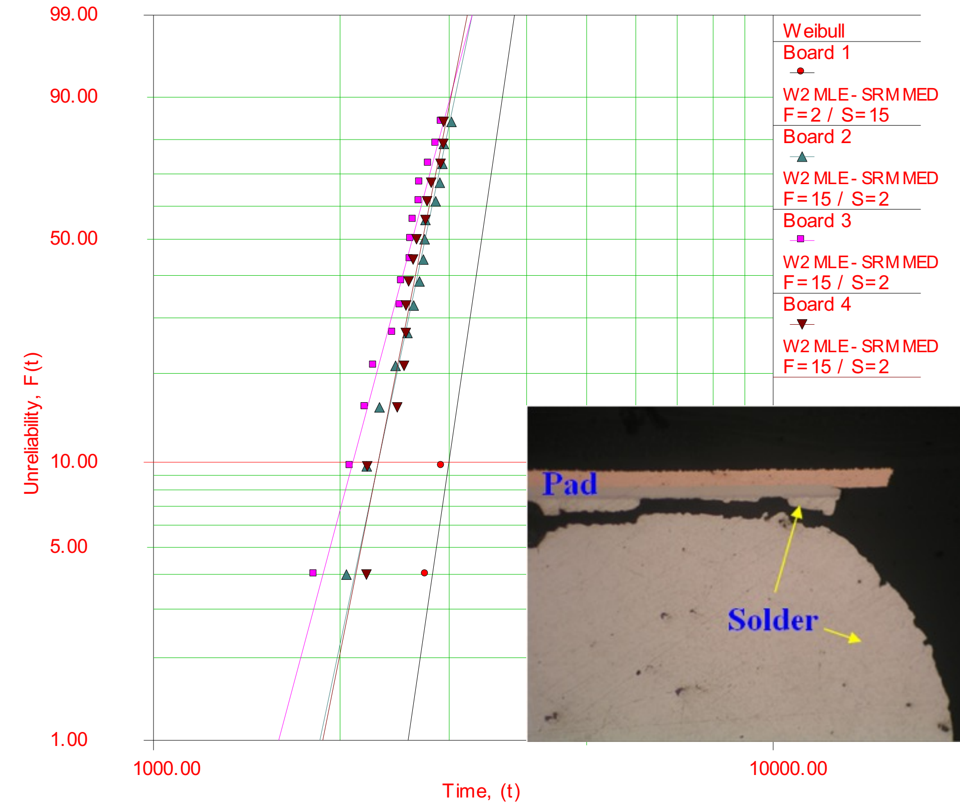


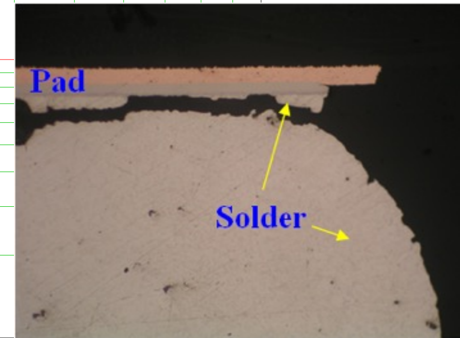


Board Level Reliability Test (ATC)



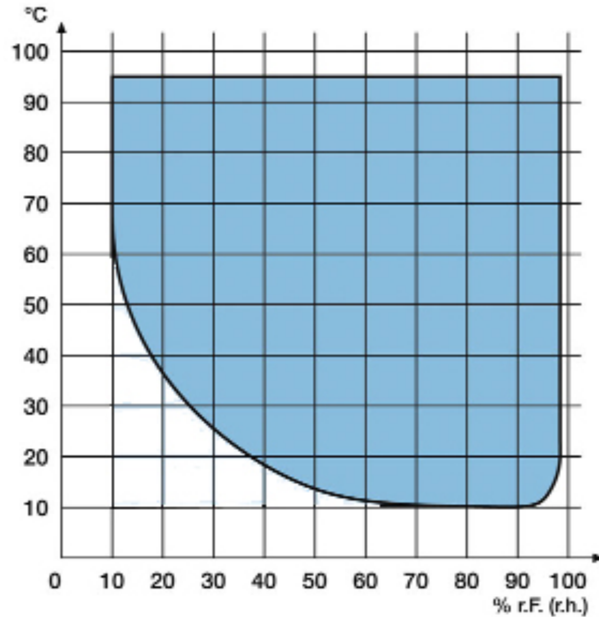






$\beta 1=15.4986, \eta 1=3466.5616$
$\beta 2=10.8255, \eta 2=2838.8649$
$\beta 3=8.5213, \eta 3=2731.6031$
$\beta 4=11.4088, \eta 4=2807.5367$

Environmental Chambers



Humidity Chamber

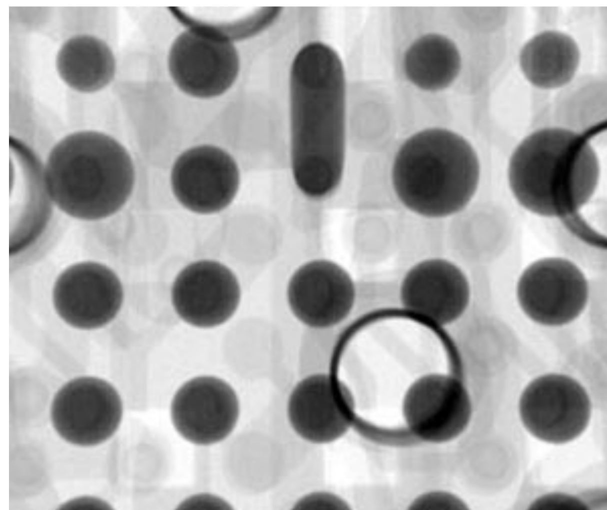
- Chamber size: W350 × D300 × H310 mm
- Maximum temperature: 180 °C
- Minimum temperature: -40 °C
- Maximum ramp up rate: 4 °C/min
- Maximum ramp down rate: 6 °C/min

HAST

- Interior dimension: 350 mm × 430 mm × 350 mm
- Temperature range: 105.0 ~ 142.9 °C
- Humidity range: 75% ~ 100% RH
- Pressure: 0.02 ~ 0.196 MPa

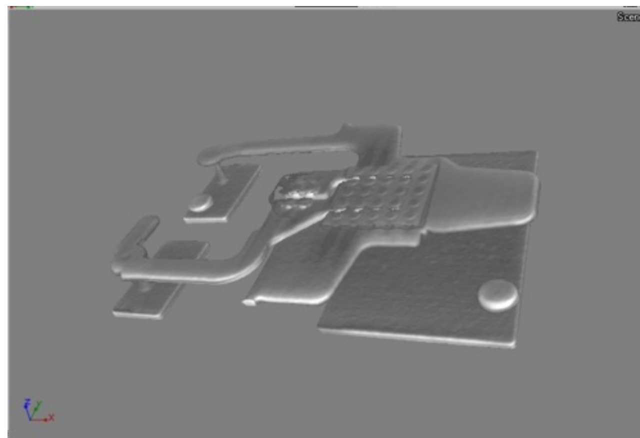
Failure Analysis (Non-Destructive)

X-RAY

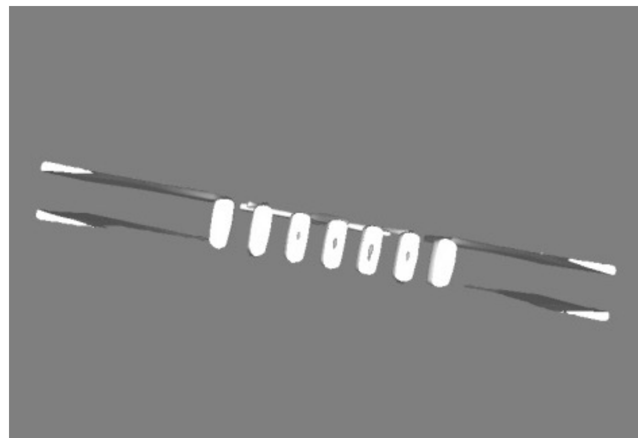


2D X-Ray

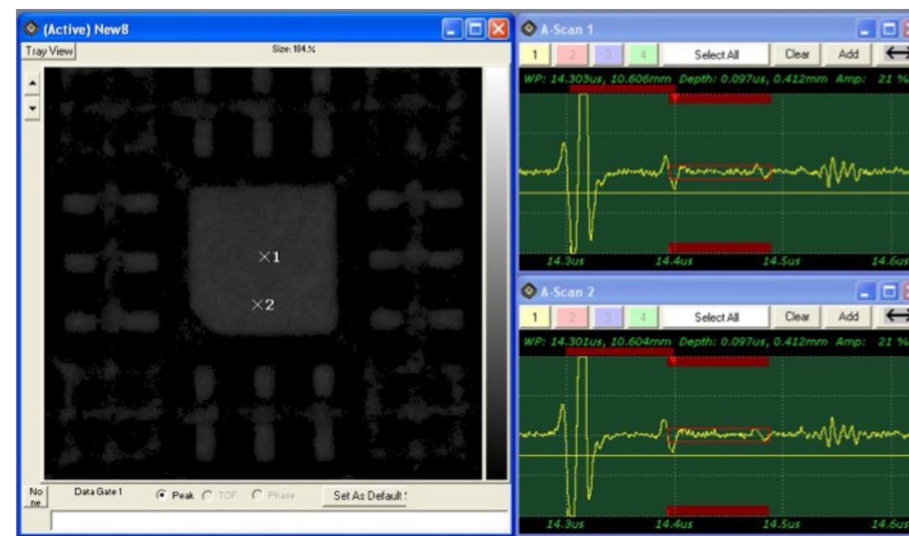
Scanning Acoustic Microscopy (SAM)



3D X-Ray

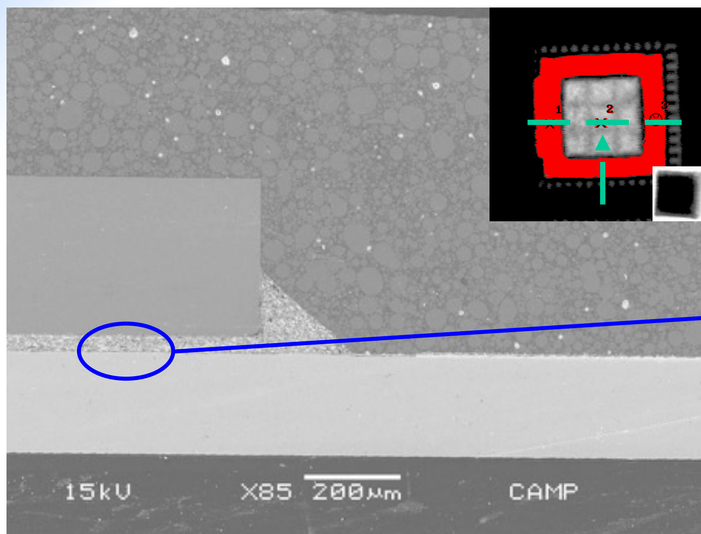


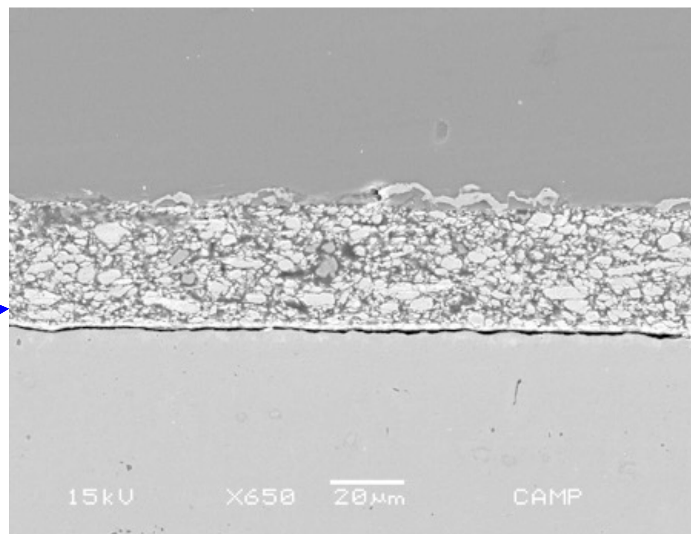
3D X-Ray Cross-Section

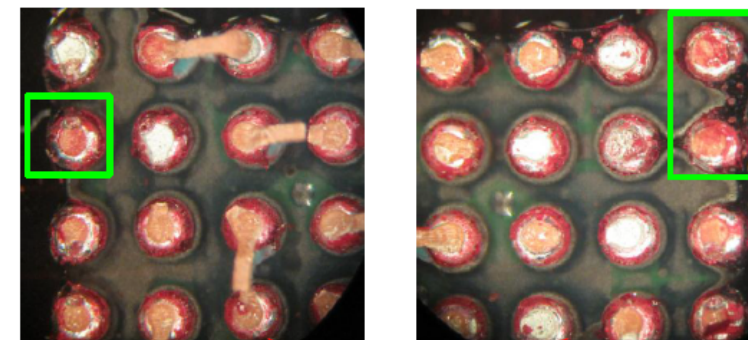


A-Scan & C-Scan

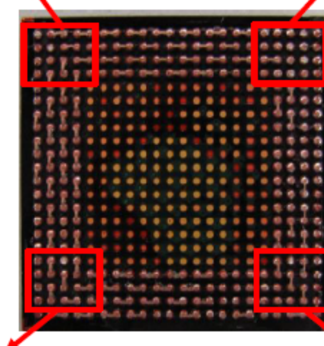
Failure Analysis (Cross-Section and Dye Penetration)

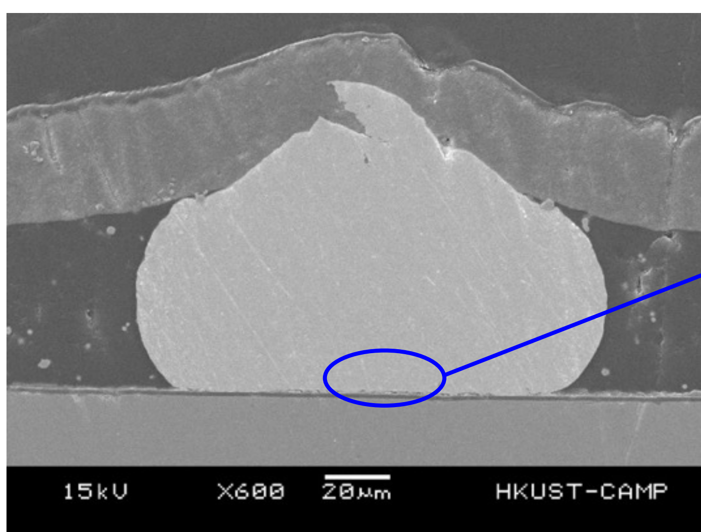


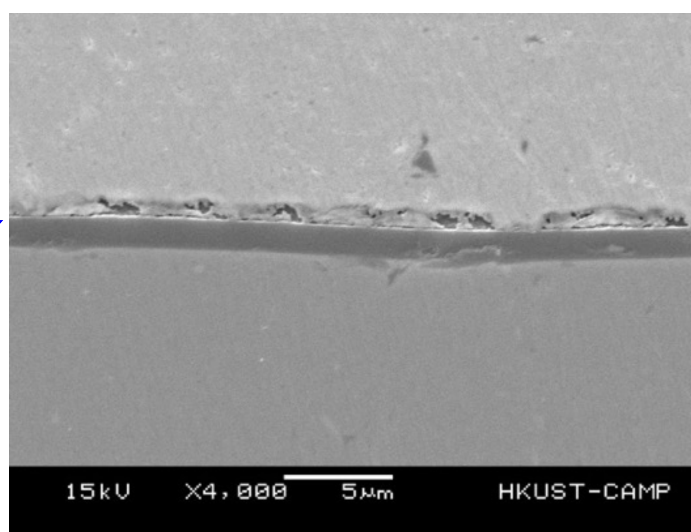


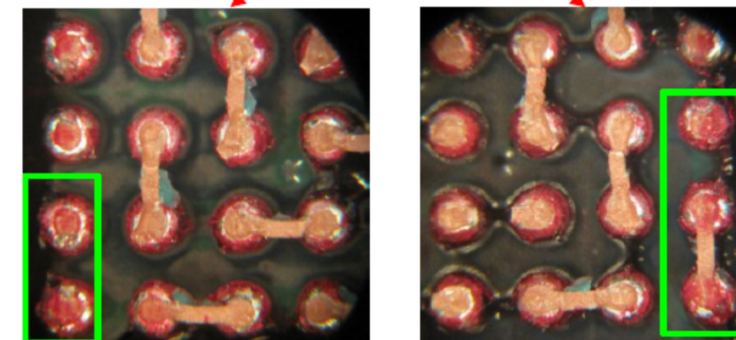


Package

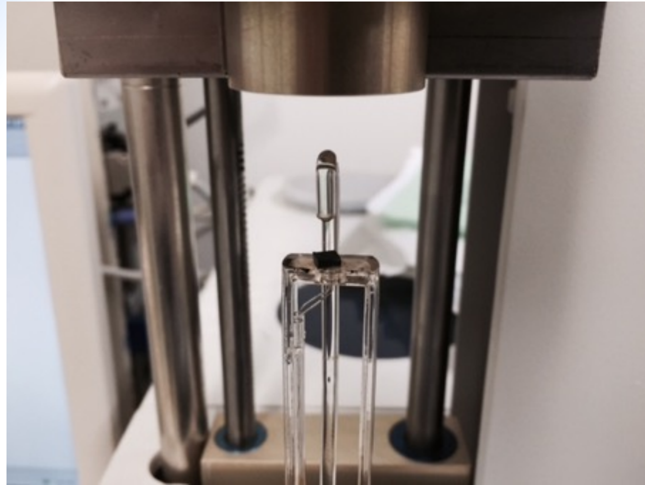


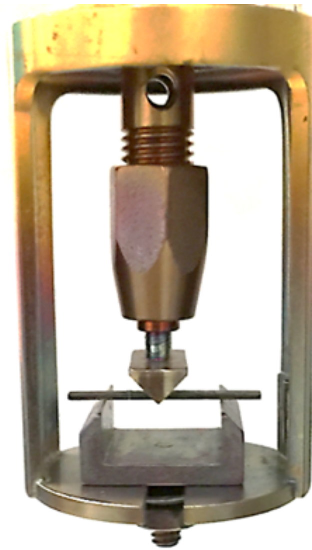


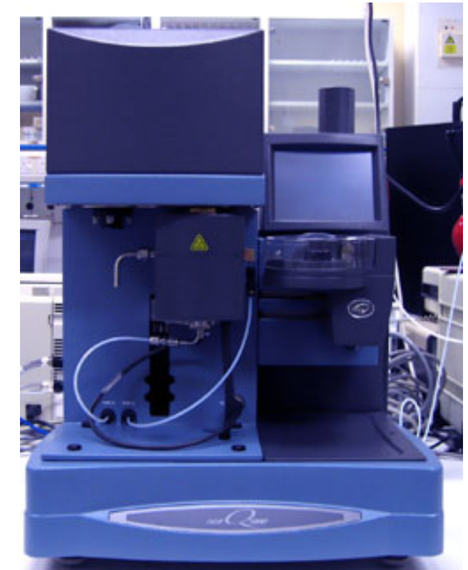


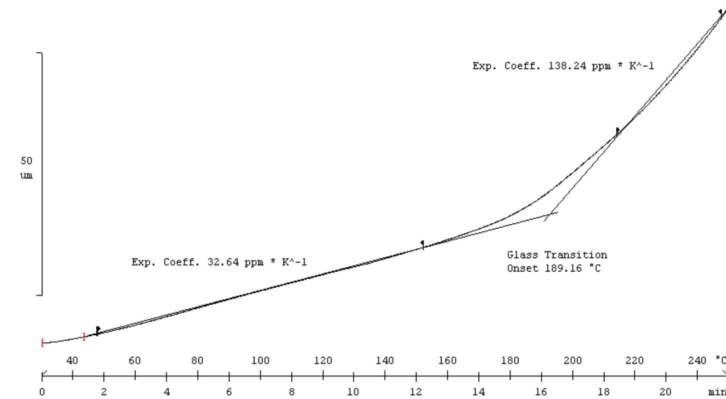


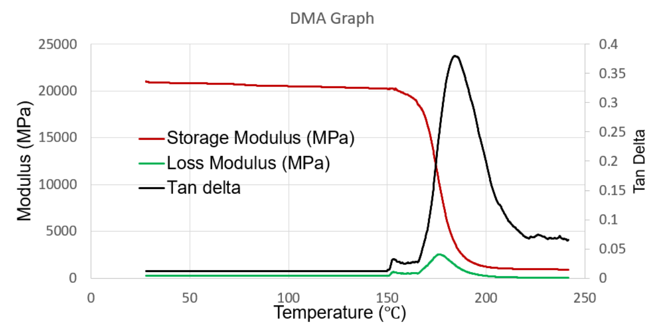
Material Characterizations (Thermal Analysis)

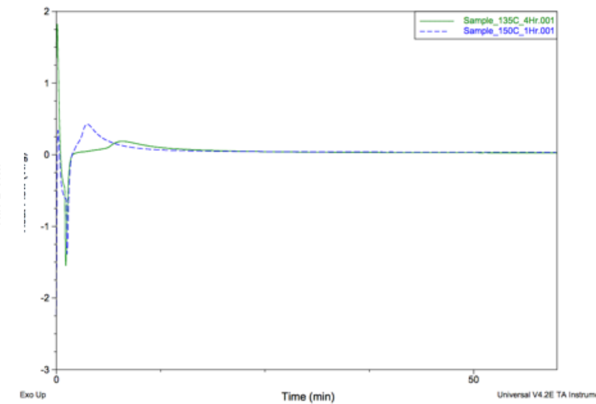


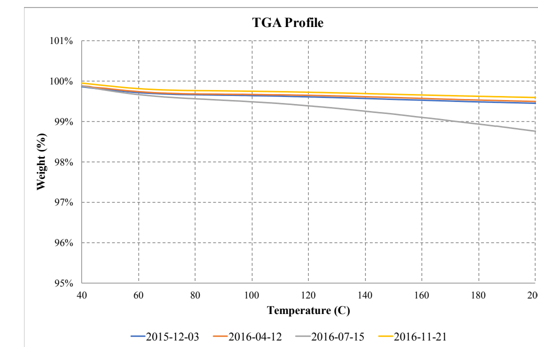












TMA

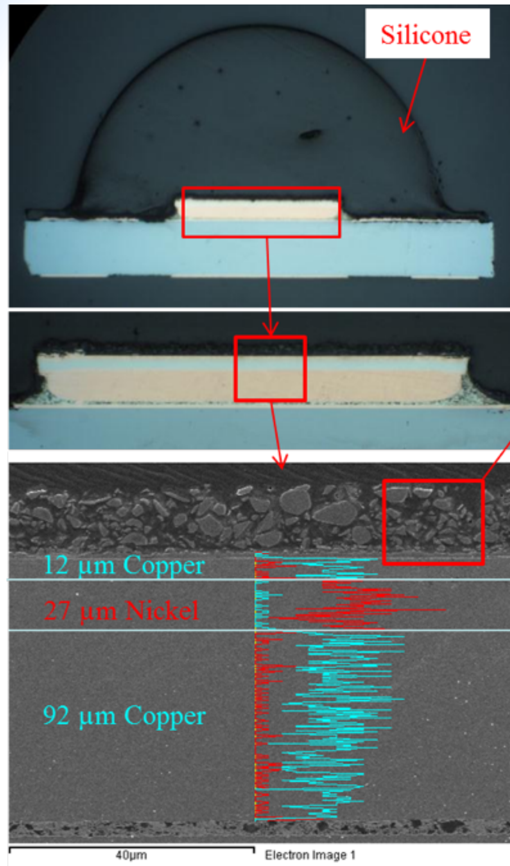
DMA

DSC

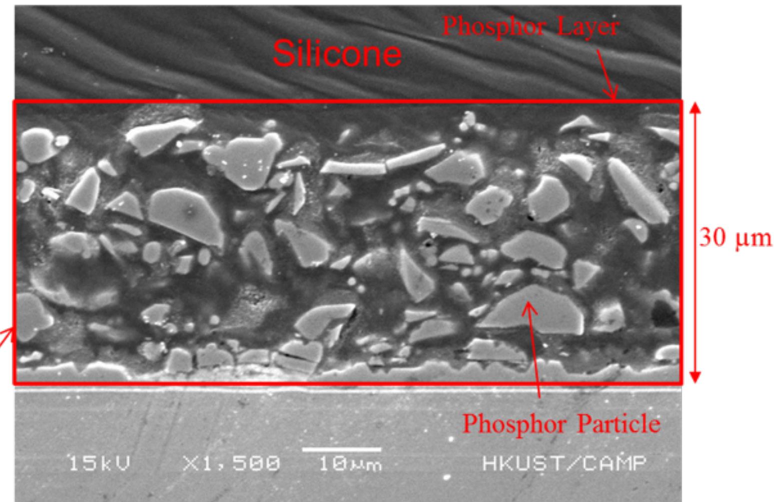
TGA

先進微系統封裝中心
Center for Advanced Microsystems Packaging

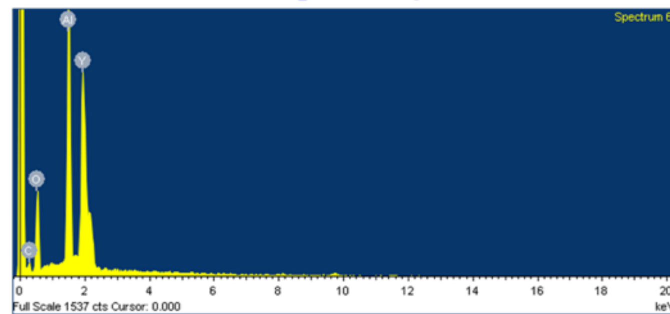
Material Characterizations



LED Chip

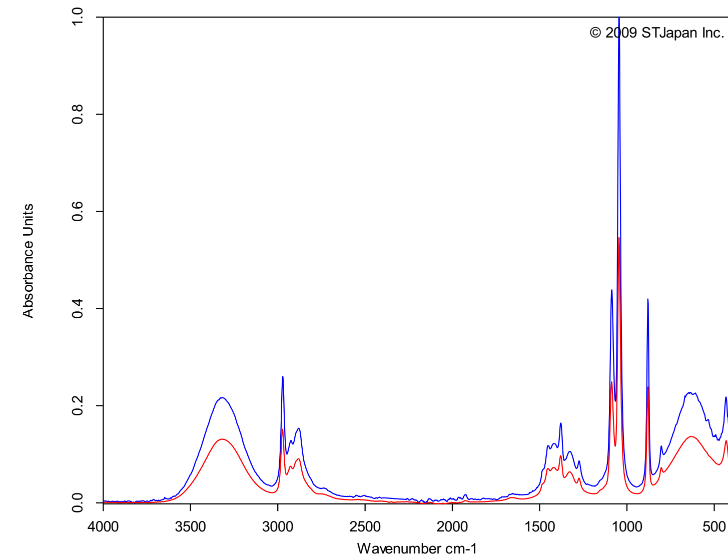


Phosphor Layer



Phosphor Particle (Yttrium + Aluminum)

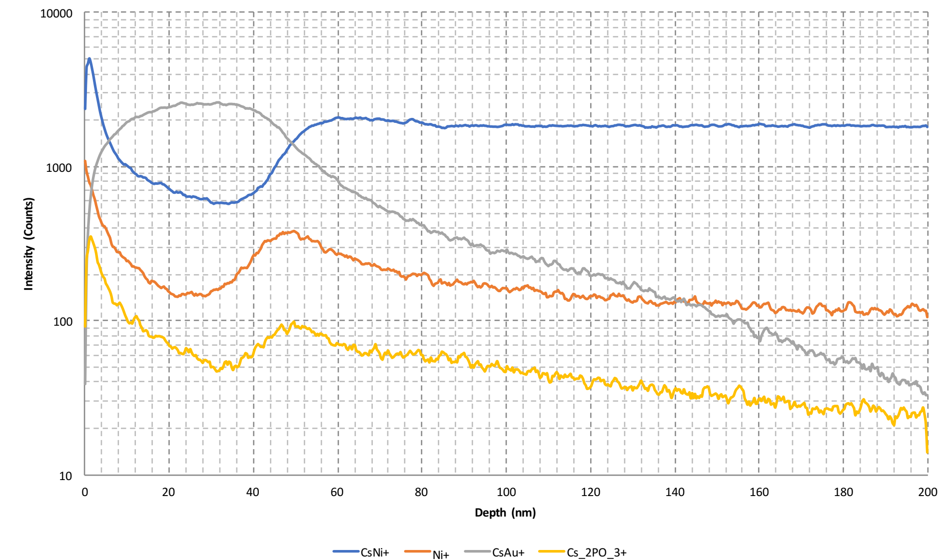
SEM/EDX Inspection



Compound information	
Compound Name	ETHYL ALCOHOL
Molecular Formula	C2H6O1
Molecular Weight	46.07
CAS Registry Number	64-17-5
Other Names	ETHANOL
Sample Preparation	ATR single bounce
Comment	hazardous
Reference	J01300/ A00298
Copyright	(c) 2012 STJapan Inc.

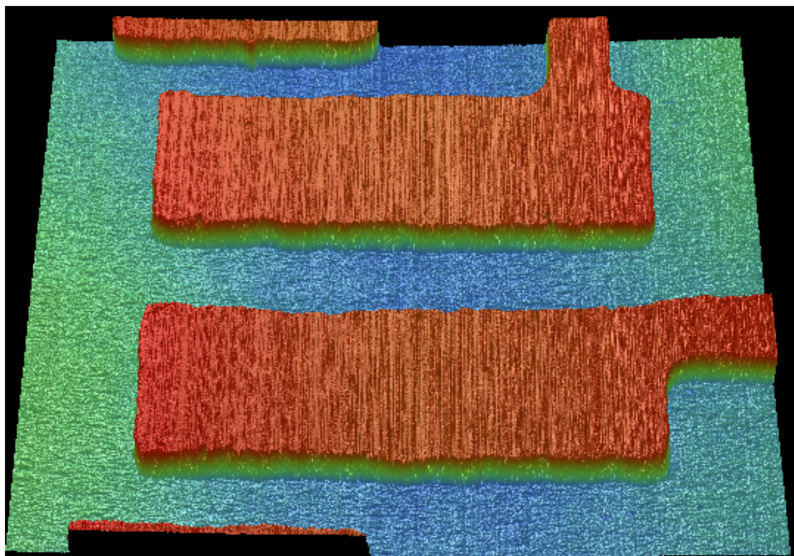
ETHYL ALCOHOL

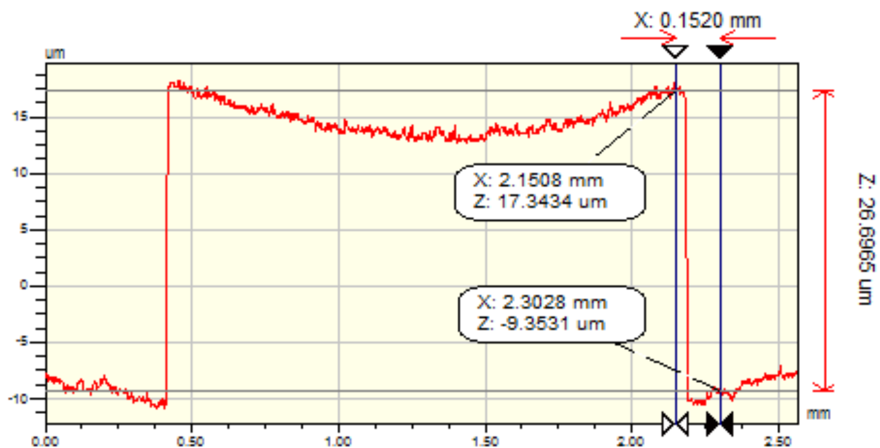
FTIR



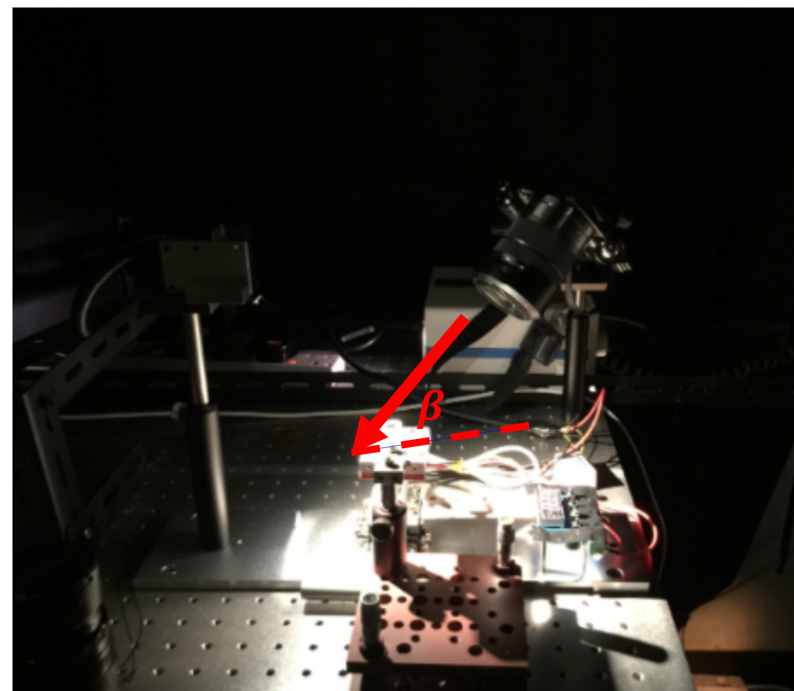
SIMS Depth Profile

Roughness and Warpage Inspection

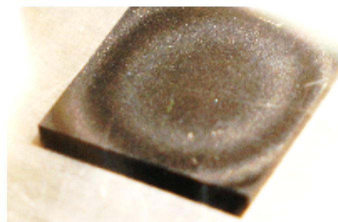




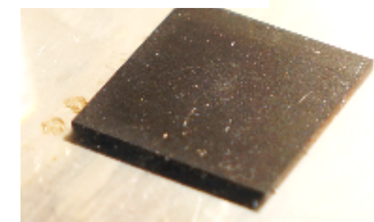
Surface Profiler



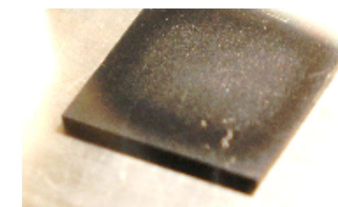
100℃ w= -50μm



175℃ w= 0μm

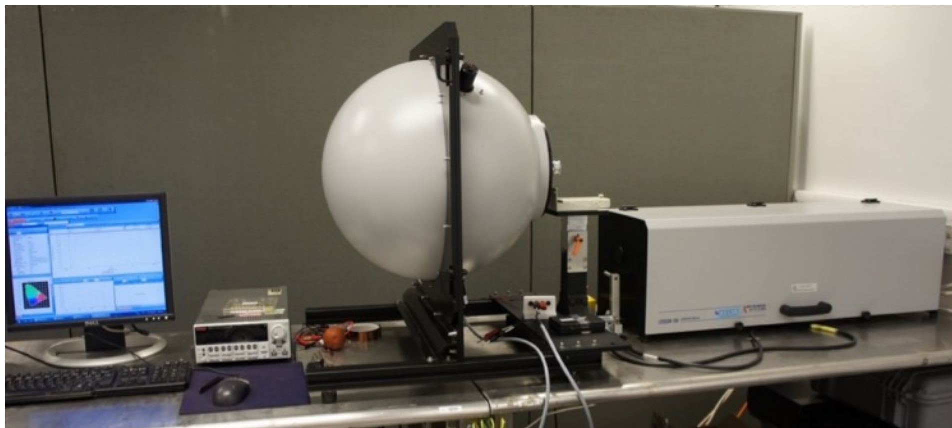


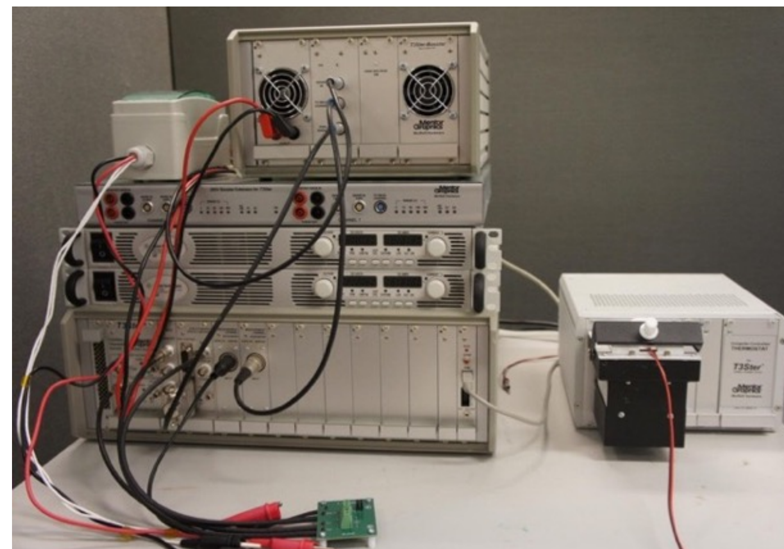
200℃ w= 30μm

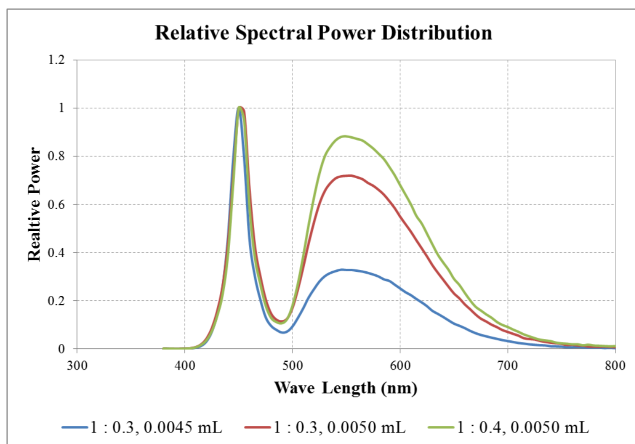


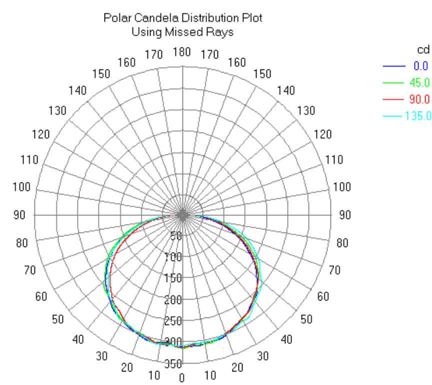
Shadow Morrie

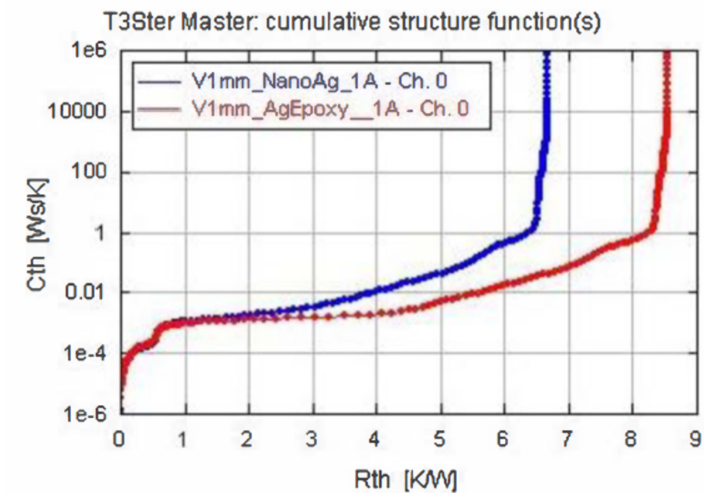
Optical and Thermal Characterizations



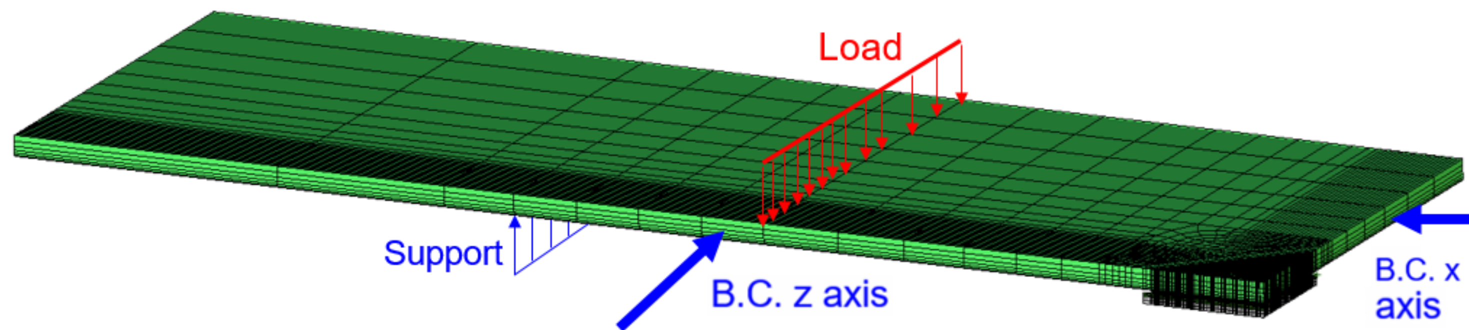




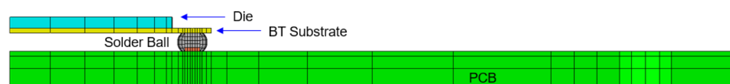


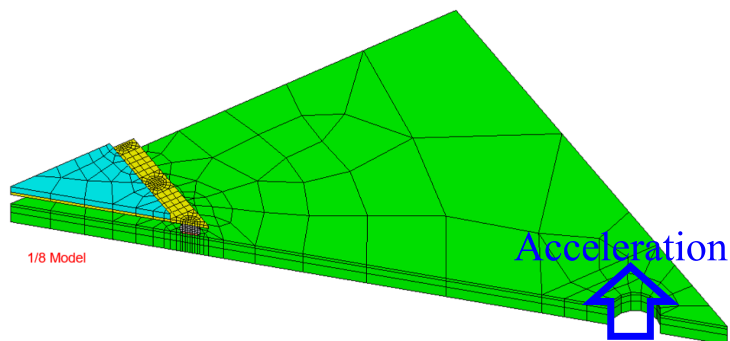


Mechanical Simulation

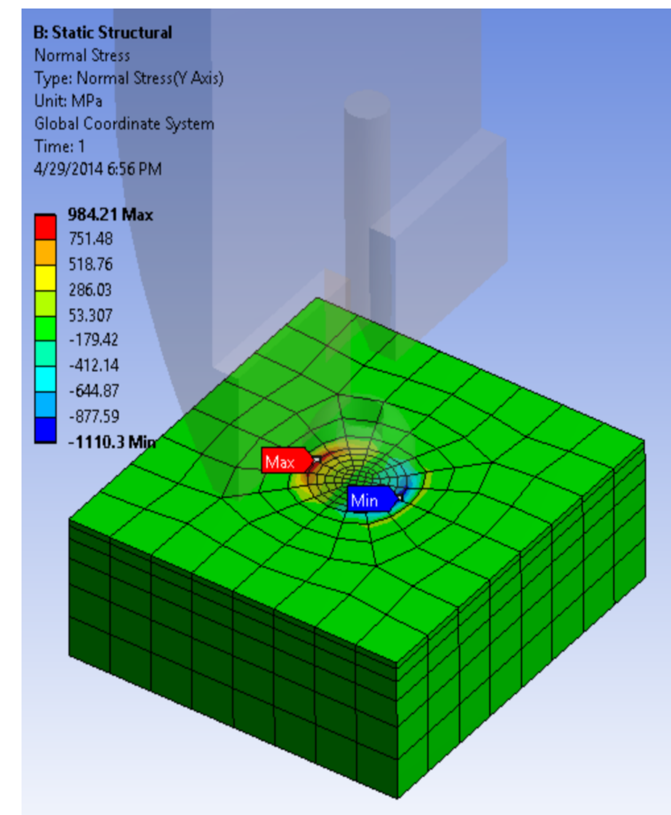


Monotonic/Cyclic Bending



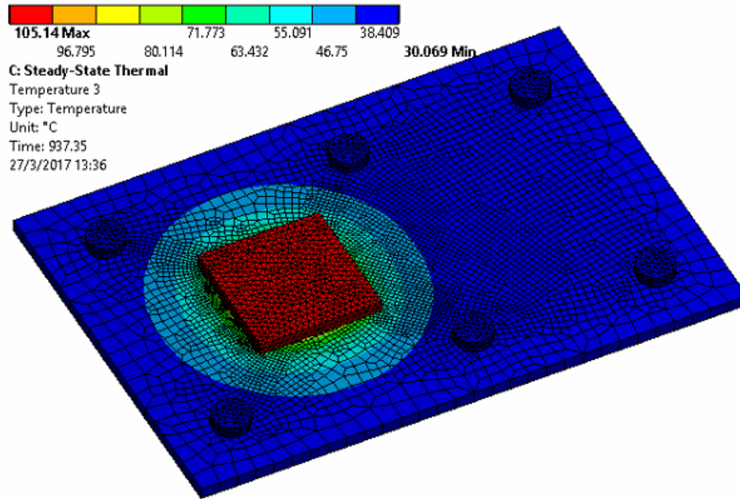


Board Level Drop

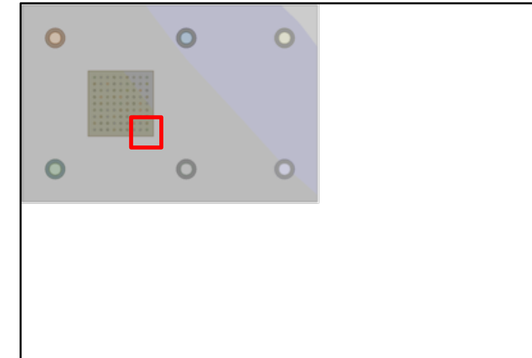


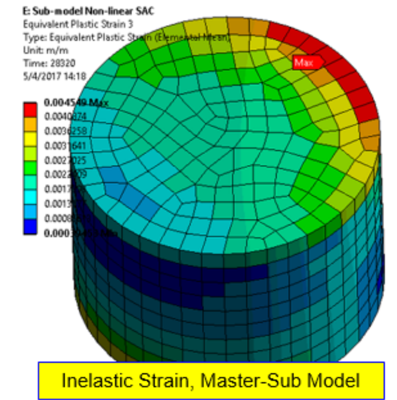
Pin Pull/Shear

Thermo-Mechanical Simulation

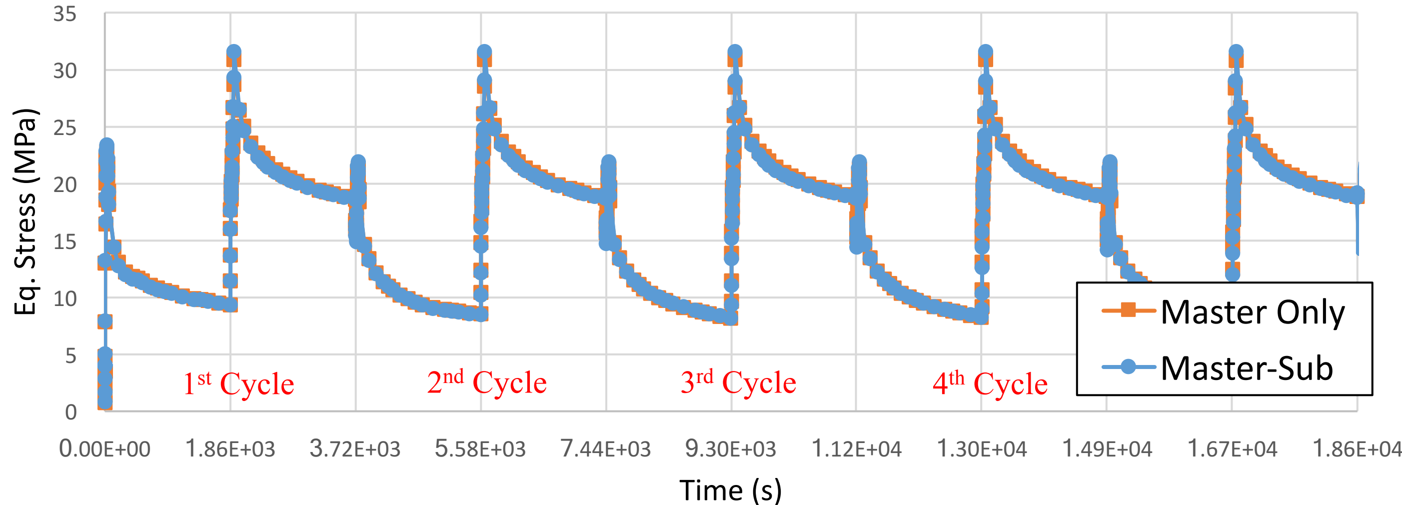


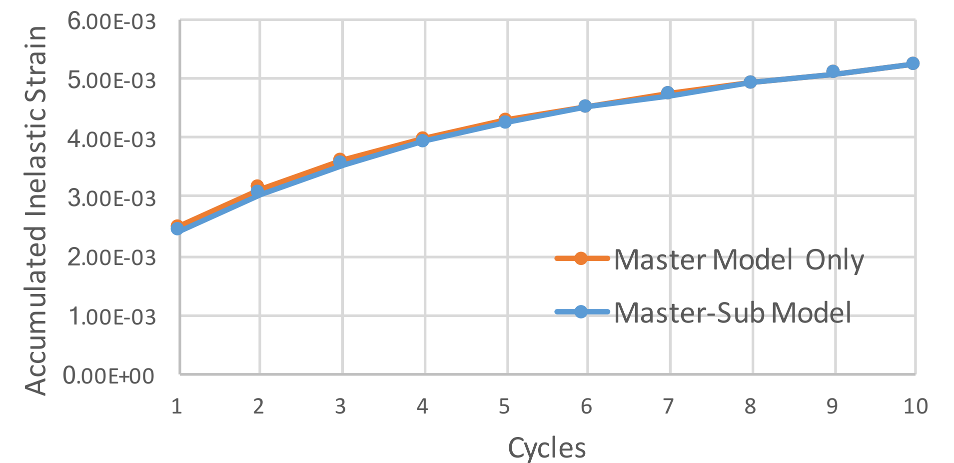
Temperature Distribution under Power Cycling



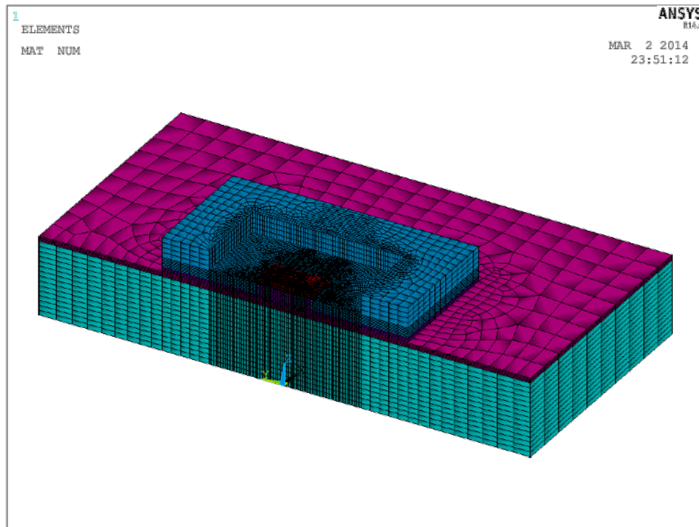


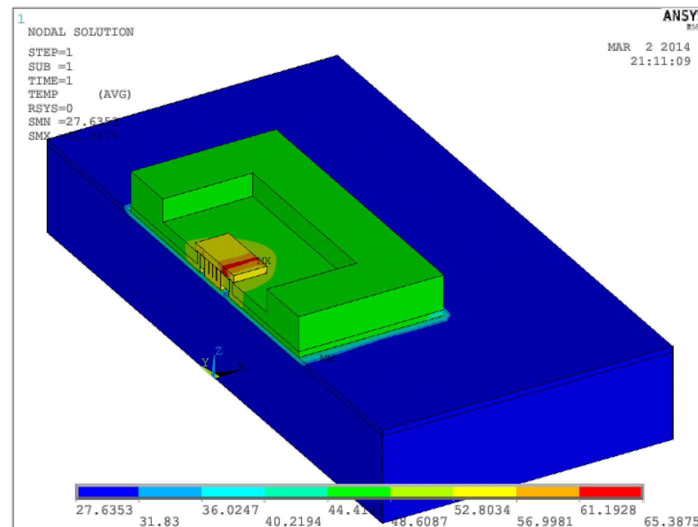
Inelastic Strain on Solder Bump

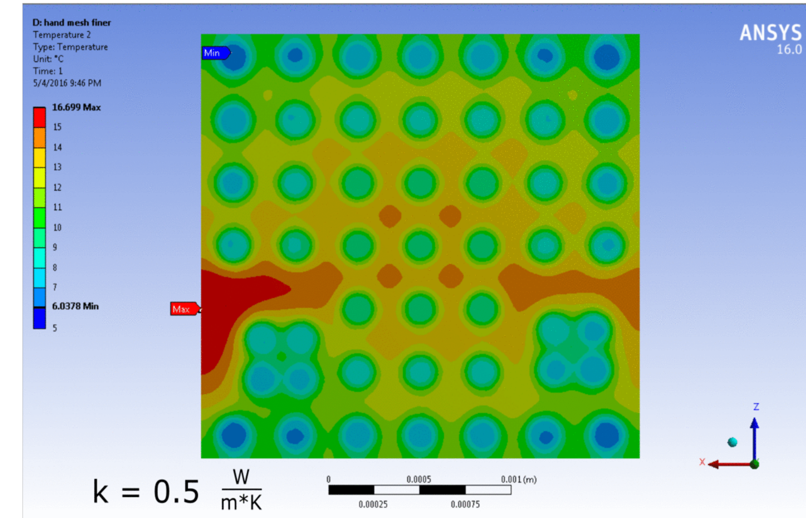


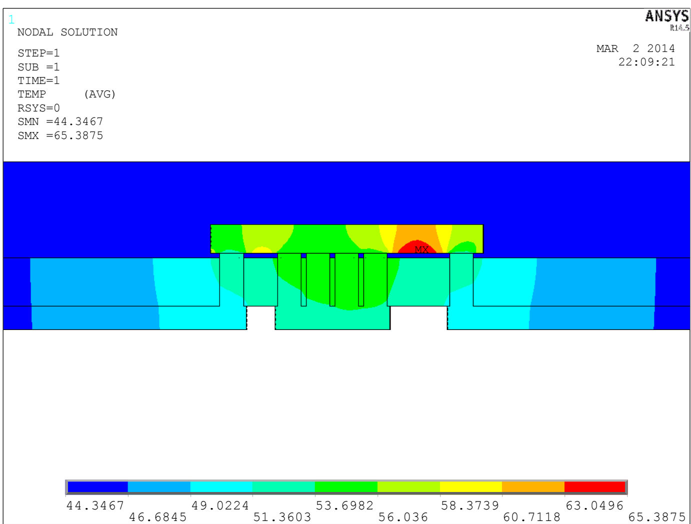


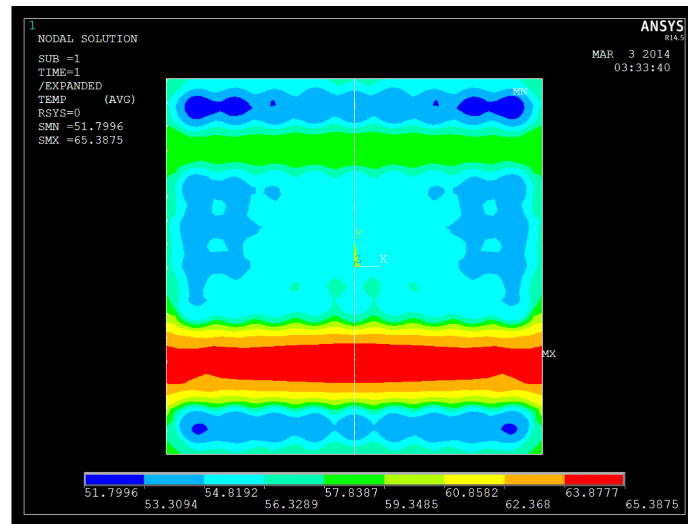
Thermal Simulation

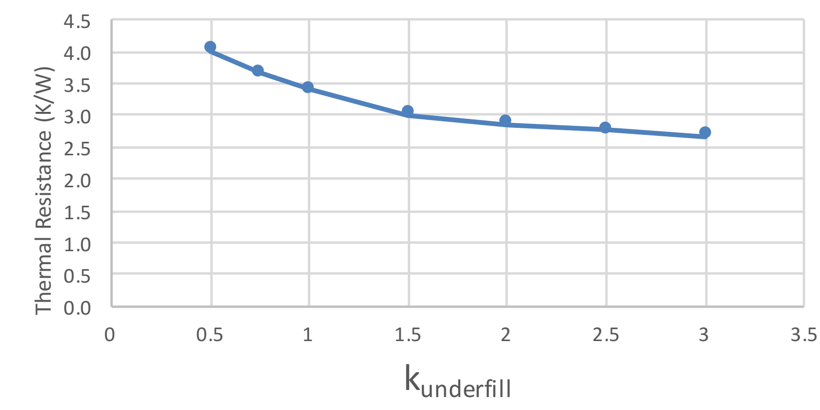










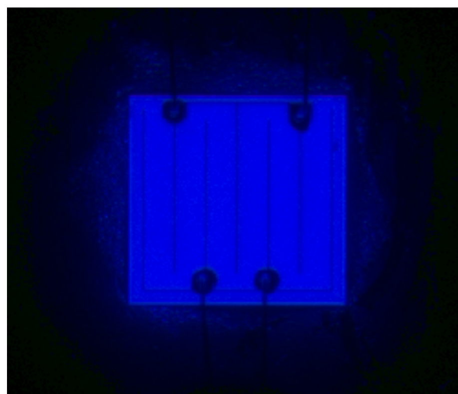


Optical Simulation

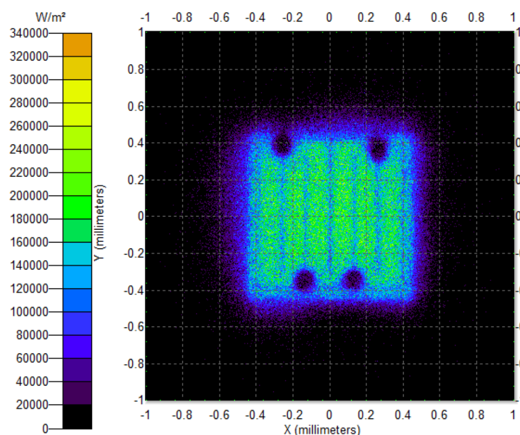
Source Imaging Goinophotometer

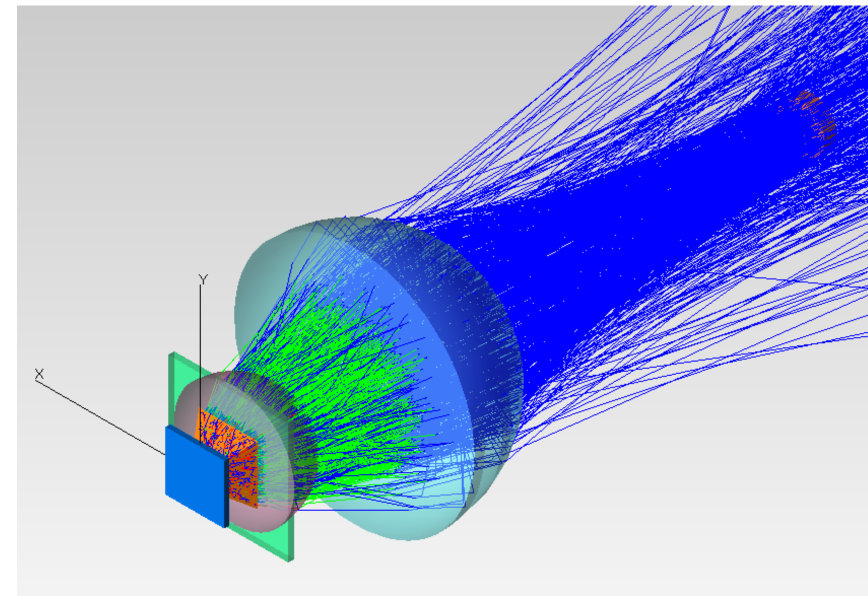
Source File

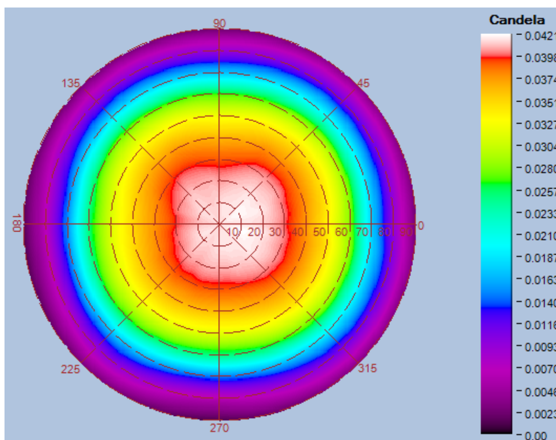
Ray Tracing Simulation

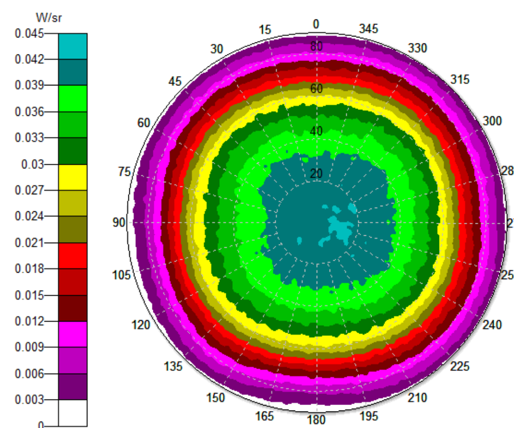


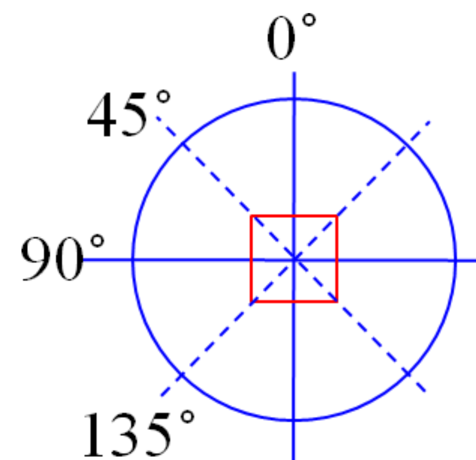
Bare chip

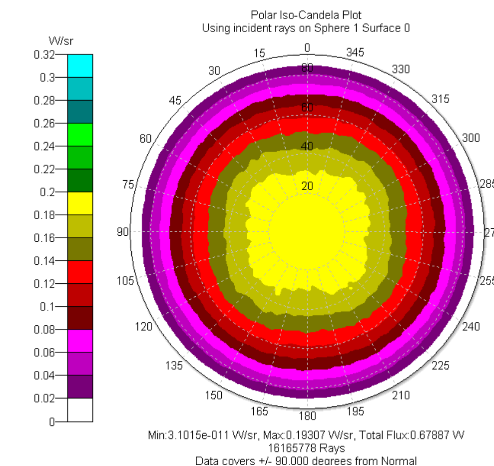












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