MAXQFP:
NXP NEW PACKAGE PLATFORM FOR AUTOMOTIVE APPLICATION

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SECURE CONNECTIONS FOR A SMARTER WORLD

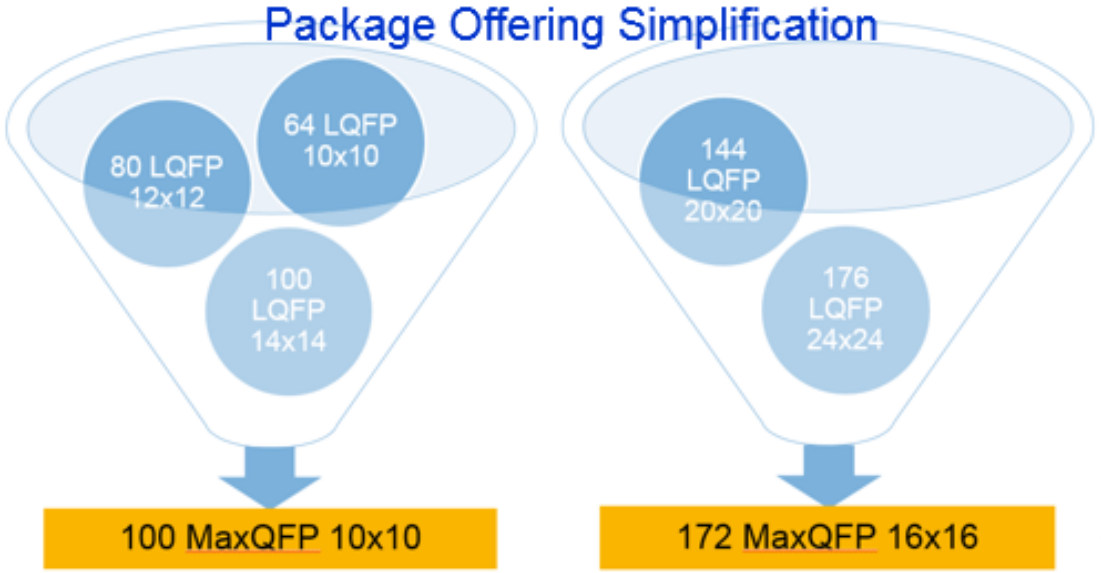
INTRODUCTION

- MAXQFP:
  - Combined PLCC J- and LQFP Gull swing (GW) leads
  - Same PCB design rules (0.1/0.1 line/space) as 0.5 mm pitch QFP; no additional PCB cost adder

- Benefits:
  - Up to 56% package body size reduction resulting in reducing board cost .
  - 2x IO in similar size package, or ½ package size with similar IO counts (172 MAXQFP in 16x16 mm vs 176 LQFP in 24 x 24 mm)
  - Package portfolio simplification

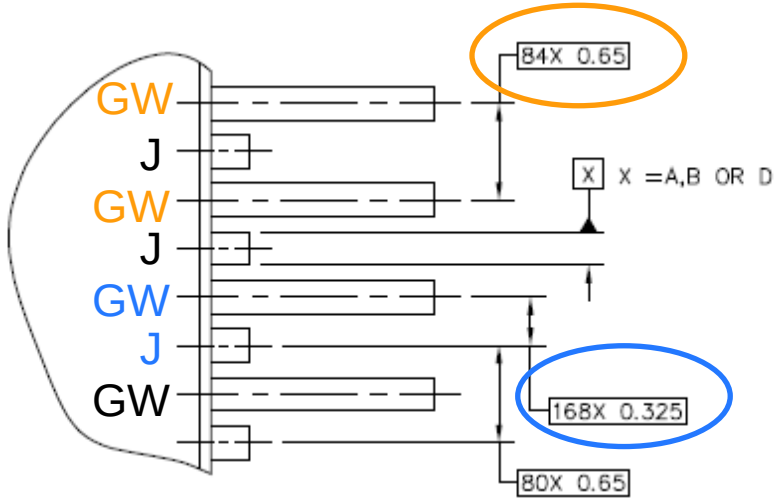
- Availability: 172/100 MAXQFP, 172 MAXQFP_EP

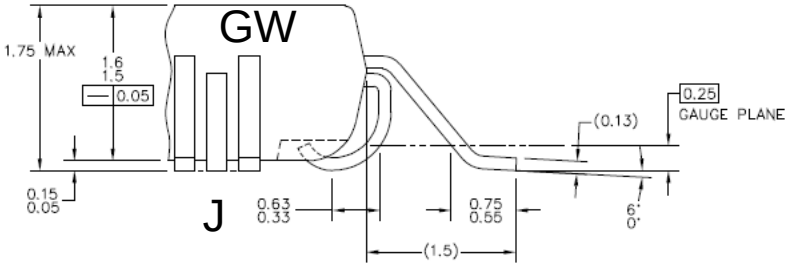
56% body size reduction vs regular LQFP

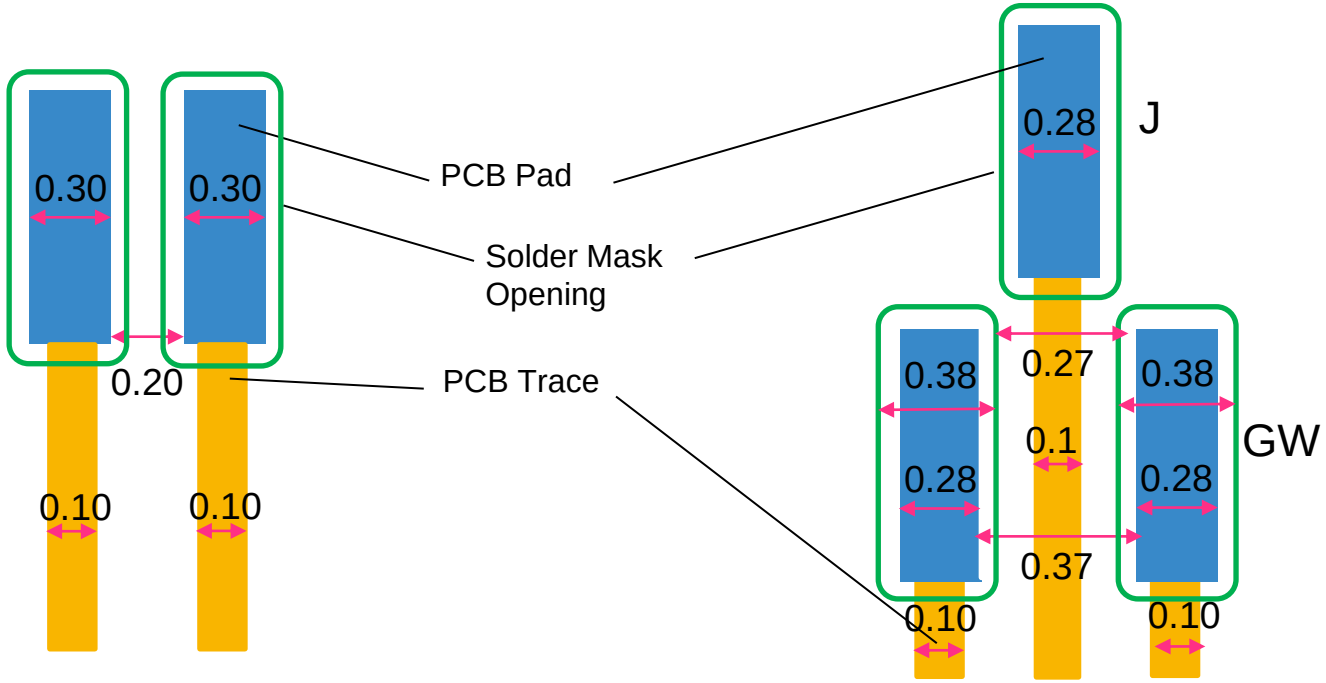


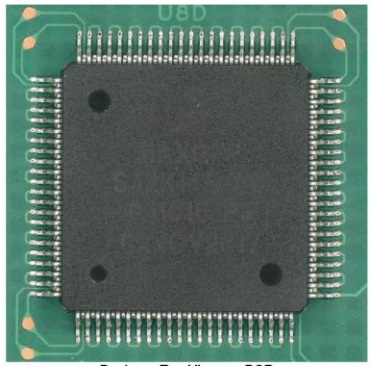
PCB FOOTPRINT DESIGN

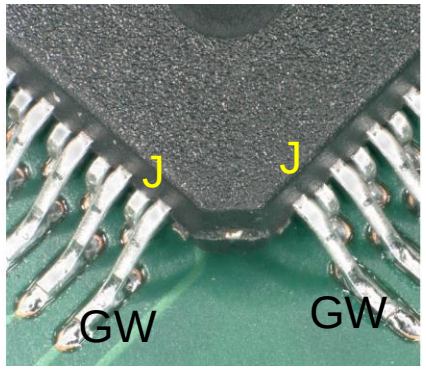
- External lead pitch at the same types of leads, e.g. J- or GW (gullwing) leads is 0.65 mm. Shortest distance between two leads (J and GW leads) is 0.325 mm.
- The edge leads are always be GW leads and J-leads are in between.
- Re-use 0.5 mm QFP PCB designs (0.1/0.1mm line/space) for MAXQFP, No change at end customer - no additional PCB cost
- MAXQFP PCB footprint width is recommended 0.28 mm.











0.5mm Pitch LQFP

0.65mm Pitch MaxQFP

ASSEMBLY MANUFACTURING

- MAXQFP uses standard QFP assembly equipment, process and standard bill of materials (BOM):
  - One process modification is required: Deflash
- However, it obviously needs some tool modification at
  - Mold tools
  - Trim & Form tools
- MAXQFP l/f design is a key to the success.

Process flow	Package type	
	LQFP	MaxQFP
Back grind		
Wafer mount		
Wafer saw		
Die bond		
Die bond cure		
Pre-wire bond plasma		
Wire bond		
Post bond inspection		
Pre-mold plasma		
Mold		
PMC		
Deflash		
Plating		
Laser Marking		
Trim/Form		

Can be shared among LQFP packages

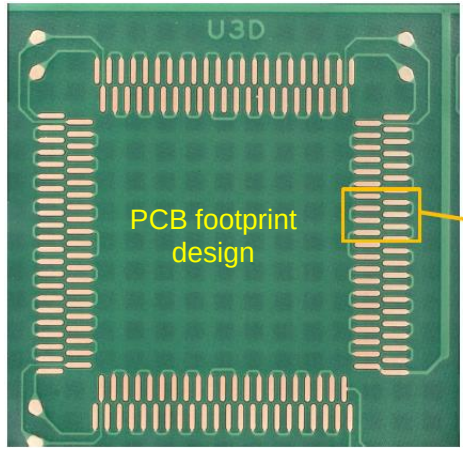
Dedicated tool per package body and IO count

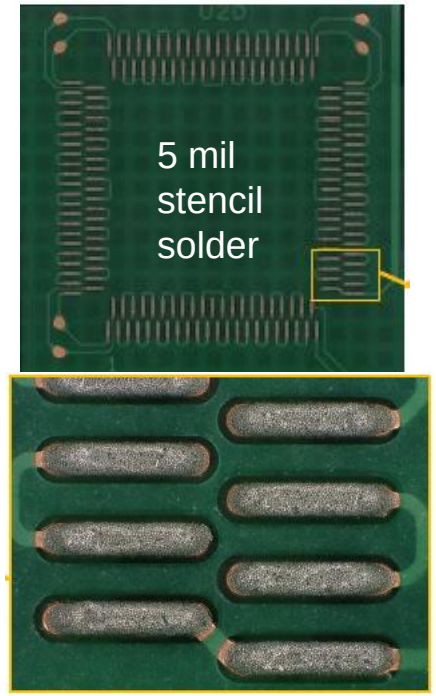
Deflash process modification

BOARD-LEVEL SOLDER JOINT RELIABILITY

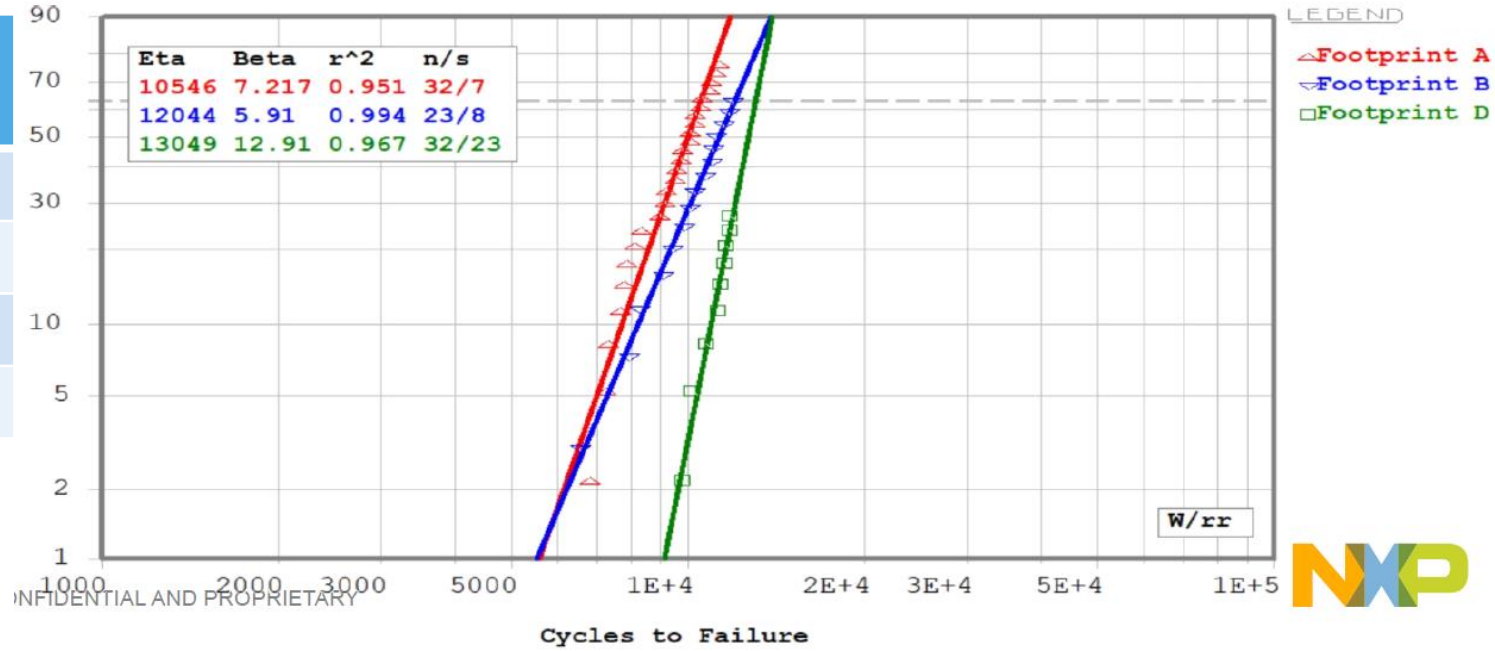
PCB PAD SIZE VARIATIONS

Footprint design	Gullwing pad length (mm)	J-lead pad length (mm)	Pad width (mm)
A	1.45	1.00	0.28
B	1.45	1.00	0.30
C (note1)	1.12	1.12	0.28
D	1.40	1.40	0.28





172 MAXQFP SJR after AATC(-40C/125C) with 5mil (0.125 mm) stencil



- Note 1: Footprint C: Removed, because of incompatibility with AOI system.
- All three footprints (A, B and D) exceed generic Automotive SJR requirement of 2000 cycle first fail.
- Footprint D (recommended for customer PCB pad design) outperforms other footprints, with first fail at **9791** cycles.
- 176 LQFP (24x24 mm) shows first fail at 3500 cycles with footprint A.
- 172 MAXQFP (16x16 mm) shows first fail at 6837 cycles with footprint A.

PACKAGE LEVEL RELIABILITY

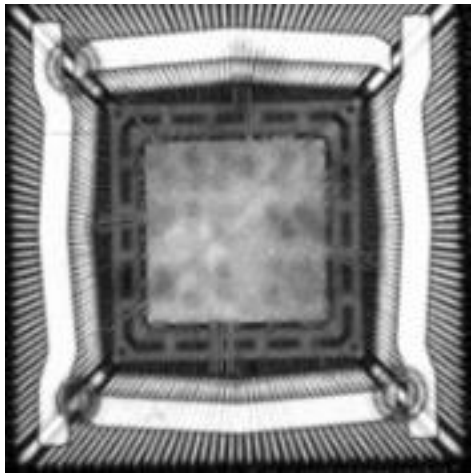
C90 nm TV (4ML), 20 um PdCu wires

Stress tests	Test condition	Sample size	Pass read points
TC	-55 to 150 C	4 x 90	1000/2000/3000 cycles
uHAST	110 C/ 85%	4 x 90	264/528 hours
THB	85C/ 85%	4 x 90	1008/2016 hours
HTSL	150 C	4 x 90	1008/2016 hours

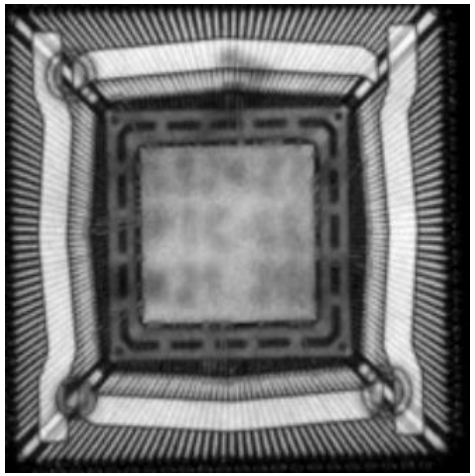
C40 nm TV (7 ML), 20 um PdCu wires

Stress tests	Test condition	Sample size	Pass read points
TC	-55 to 150 C	3x 109	1000/2000 cycles
uHAST	110 C/ 85%	3x 80	264/528 hours
HTSL	150 C	3x 85	1008/ 2016 hours

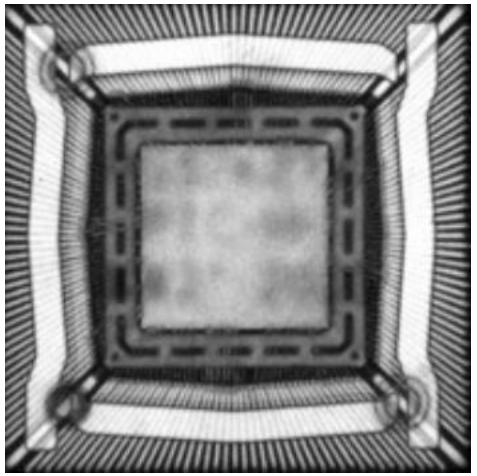
- Passing 2x AEC G1 requirements with two set of TV (C90-4ML & C40-7 ML) meeting both AEC Q100 & Q006 (Cu wire) requirements.
- Main focus is Temperature Cycling stress. It demonstrates passing TC3000 (-55 to 150C)
- Post stress CSAM images examples: No delamination. (C40 nm TV)



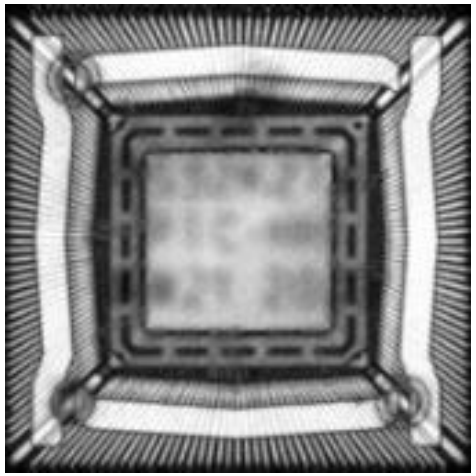
Time zero



MSL3/260



TC1000



TC2000

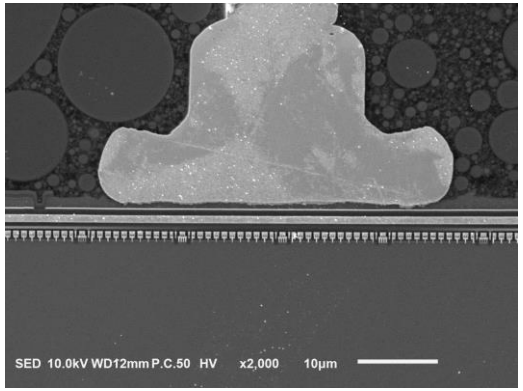
000926

PACKAGE LEVEL RELIABILITY (CONT'D)

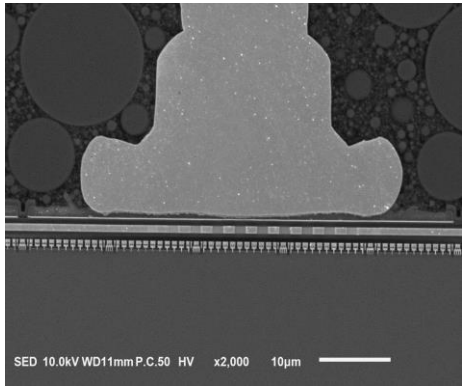
- Post TC decapulation wire pull and ball shear all passed. Results summarized at below table for C90nm TV.
- X-section/ SEM on both first and 2nd bonds

	Strip-level CZ						T0		MSL3		TC1000 (-55 to 150 C)					TC2000 (-55 to 150 C)							TC3000 (-55 to 150 C)						
	Wire pull (g)			Ball shear (g)			FT	CSAM	FT	CSAM	FT	CSAM	Wire pull (g)			FT	CSAM	Wire pull (g)			Ball Shear (g)			FT	CSAM	Wire pull (g)			Ball Shear (g)		
	Min	Max	Ave	Min	Max	Ave							Min	Max	Ave			Min	Max	Ave	Min	Max	Ave			Min	Max	Ave	Min	Max	Ave
Lot 1	6.89	8.62	7.78	21.69	29.22	24.99	Pass	Pass	Pass	Pass	Pass	Pass	5.16	7.78	6.36	Pass	Pass	3.8	10.87	6.34	18.39	26.6	22.21	Pass	Pass	4.24	8.34	5.99	20.92	34.76	26.6
Lot 2	N/A						Pass	Pass	Pass	Pass	Pass	Pass	4.99	9.07	6.07	Pass	Pass	4.65	6.84	6.05	17.77	27.73	22.85	Pass	Pass	N/A					
Lot 3	N/A						Pass	Pass	Pass	Pass	Pass	Pass	5.28	7.48	6.61	Pass	Pass	5.04	6.62	5.85	17.74	28.64	23.04	Pass	Pass	N/A					
Lot 4	7.4	9.44	7.97	20.9	27.6	24.16	Pass	Pass	Pass	Pass	Pass	Pass	3.65	6.33	5.37	Pass	Pass	5.22	7.39	5.89	19.03	27.3	23.61	Pass	Pass	4.45	7.32	6.37	20.55	32.34	26.27

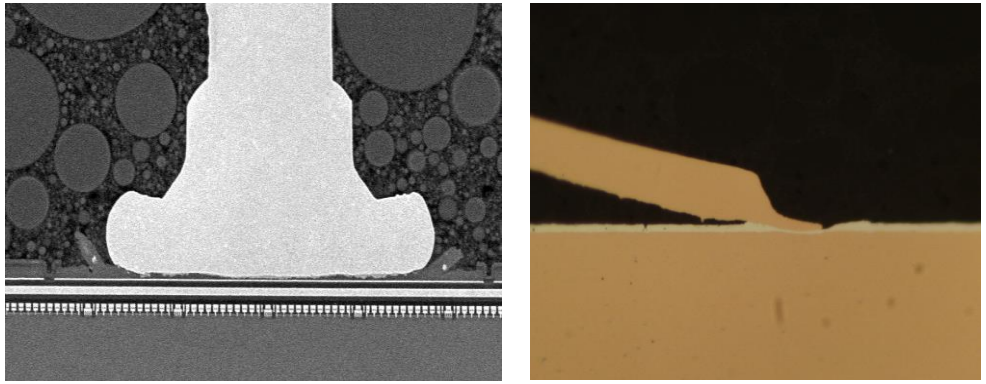
Note: min wire pull = 3 g, min ball shear = 12 g



TC1000 x-section (Lot 1)



TC2000 x-section (Lot 1)



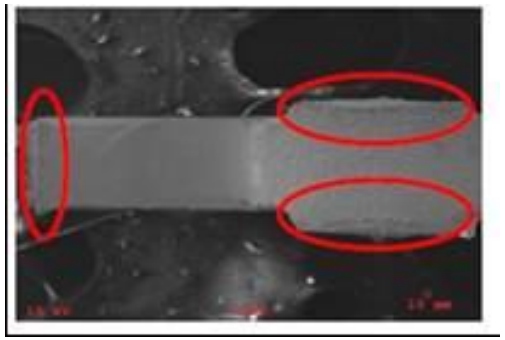
TC3000 x-section (Lot 1)

TIN WHISKER STUDY

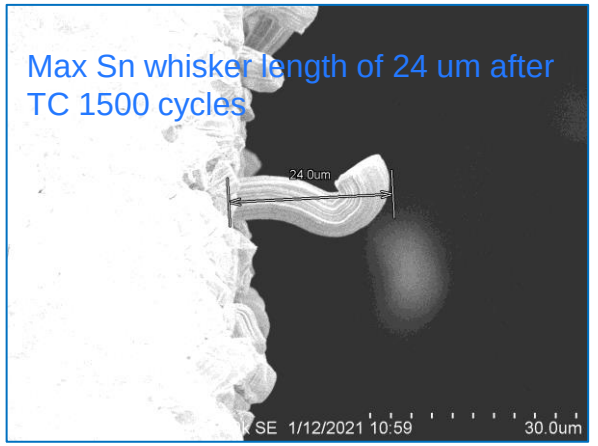
- MAXQFP has shared exact the same production line as LQFP on external lead finish.
- Unlike LQFP, MAXQFP does not have lead-shoulder-Cu-exposure sites which are the Sn whisker initiation area. Less chance to have Sn whisker than LQFP.
- NXP has followed JESD201, “Environmental Acceptance Requirements for Tin Whisker Susceptibility of Tin and Tin alloy surface Finishes” (available at http://www.jedec.org), first released on Mar 2006.
- All NXP LQFP products have passed JESD201 requirements since 2006.

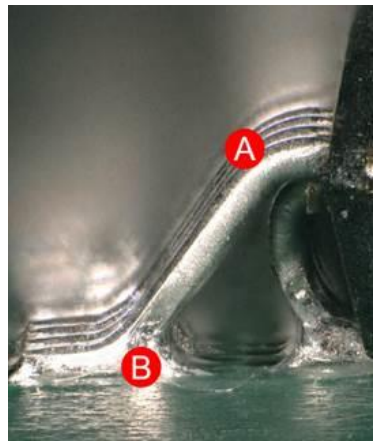
Stress types	Test Conditions	Read points	Criteria
Temp Cycling	-55 to 85 C	1500 cycles	45 um
Temp Humidify Storage	30C/ 60 % RH	4000 hours	40 um

- MAXQFP Sn whisker test results (TC): Maximum Sn whisker length is 24 um at location B of GW lead where deformation was made. It meets our theory and data observed at LQFP leads. It indicates re-use of LQFP Sn whisker data. THS data: Q3 2021.



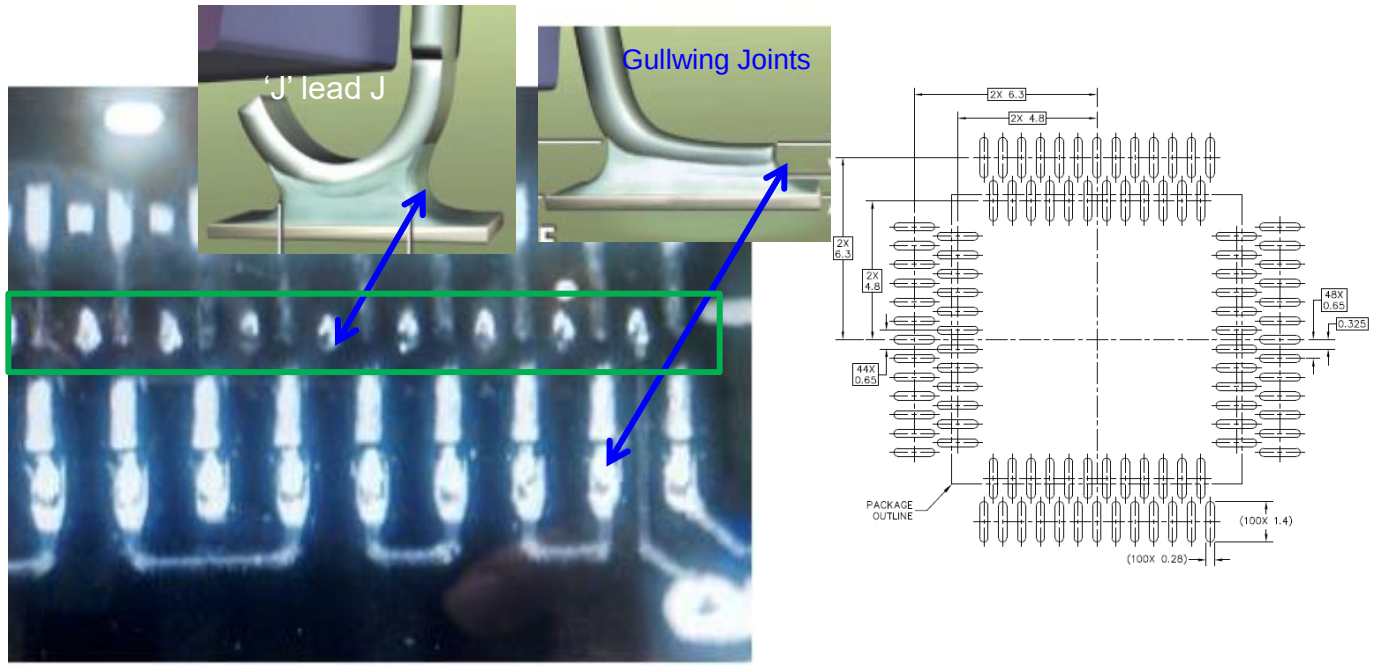
Standard LQFP has lead shoulder Cu exposure which serve as a Sn whisker preference sites.

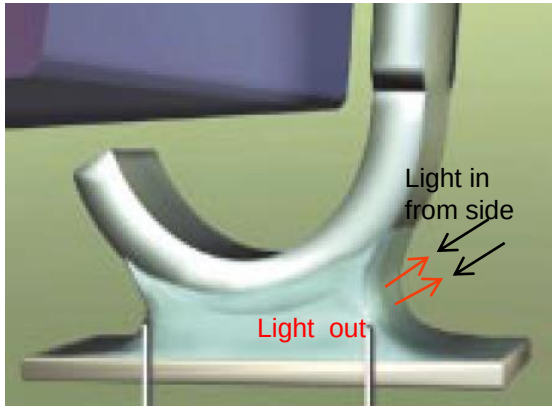


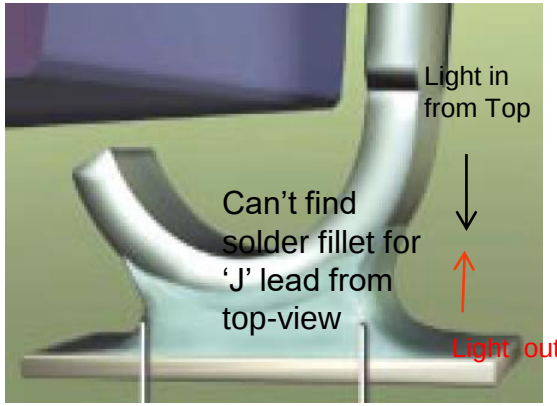


AOI SYSTEM FOR MAXQFP

- AOI system requires side camera (3D AOI) to directly inspect J-lead solder joints for MAXQFP packages.
- Conventional 2D system uses either pattern- or algorithm-matching types for solder joint inspections. Not a direct inspection.
- Examples of MAXQFP solder joint images using 3D AOI systems:



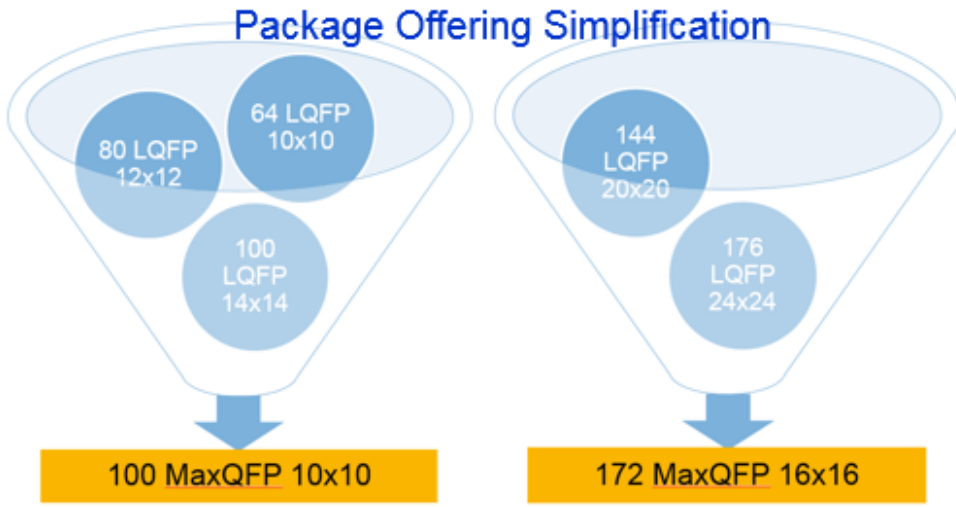




Schematic example of 3D AOI system

CONCLUSION

- MAXQFP combined both PLCC J- and LQFP GW- leads and are successfully qualified and production ready.
- MAXQFP advantages over standard LQFP/QFP:
  - Small body size, 2X I/O counts at similar body size as LQFP (172 MAXQFP vs 176 LQFP)
  - Using same PCB design as .5 mm LQFP (0.1/0.1 mm line/space) resulting in no additional PCB cost.
  - Simplify package portfolios:
    - 100 MAXQFP (10x10): LQFP 64 (10x10), 80 (12x12) and 100 (14x14).
    - !72 MAXQFP (16x16): LQFP 144 (20x20) and 176 (24x24).
    - Also offering MAXQFP_EP (exposed pad) for high power application.
- Demonstrate passing 2x AEC G1 requirement at package-level.
- PCB board level reliability: Exceeding AEC G1 requirement
- AOI system: Requires 3D AOI system for direct SJ inspection.
- Future works:
  - JEDEC registration
  - AEC G0 mission profile/ application.
  - Full HVM launch at 2022.



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