Reliability of eWLB (embedded wafer level BGA) for Automotive Radar Applications

by

Daniel Yap, Kim Sing Wong, Luc Petit*,
Roberto Antonicelli and Seung Wook Yoon*****
STMicroelectronics Pte Ltd. 629 Toa Payoh, Lorong 4, Singapore 319521
***STMicroelectronics, 12 rue Jules Horowitz, B.P. 217, 38019 Cedex, Grenoble, France**
**** STATS ChipPAC, Rue de Lausanne 47 1110, Morges, Switzerland**
*****STATS ChipPAC Pte Ltd., 10 Ang Mo Kio Street 65 Techpoint #04-08/09, Singapore**

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Abstract— **With shrinking of chip sizes, Wafer Level Chip Scale Packaging (WLCSP) becomes an attractive and holistic packaging solutions with various advantages in comparison to conventional packages, such as Ball Grid Array (BGA) with flipchip or wirebonding. With the advancement of various fan-out (FO) WLPs, it has been proven to be a more optimal, low cost, integrated and reliable solution compared to fan-in WLP because of the greater design flexibility in having more input/output (I/O), improved mechanical and thermal performance. In addition, FO-WLP shows superior high-frequency electrical performance due to its shorter, finer and simpler interconnection scheme compared to flipchip packaging. eWLB (embedded wafer level BGA) is a type of FO-WLP that enables applications requiring smaller form factor, excellent thermal performance and thin package profiles and it has the potential to evolve into various configurations with proven yields and manufacturing experience based on more than 8 years of high volume manufacturing of over 1.5B unit shipment.**

This paper discusses the recent advancements in robust board level reliability performance of eWLB for automotive application, where a review of a Design of Experiment (DOE) study will demonstrate improved Temperature Cycle on Board (TCoB) reliability. Several DOE studies were planned and test vehicles were prepared with various variables, such as materials, redistribution layer (RDL) design, copper (Cu) and under bump metallurgy (UBM) thickness, and a printed circuit board (PCB) pad design. The final test vehicle passed over 1000 times temperature cycles (TC) with optimized design factors of these parametric studies and reliability tests. To investigate potential structural defects after the reliability test, both destructive analyses were performed under industry standard test conditions, Daisy chain test vehicles were used for TCoB reliability performance.

Keywords-component; FOWLP, eWLB, Automotive packaging, 77GHz ADAS packaging, Reliablity, Failure Analysis

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Emerging WLCSP market of Automotive Applications

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Advanced Wafer-Level Technology: eWLB/FO-WLP for mmWave & Automotive Radar Applications

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Test Vehicle Specification

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Items	Specification
PKG size	9x9mm
Die Size	6x6mm
Ball Pitch	0.5mm
Ball Dia	0.3mm
IO No.	230
UBM	No
Cu RDL No.	1 layer
Die Thickness	440µm
PKG Thickness	770 µm

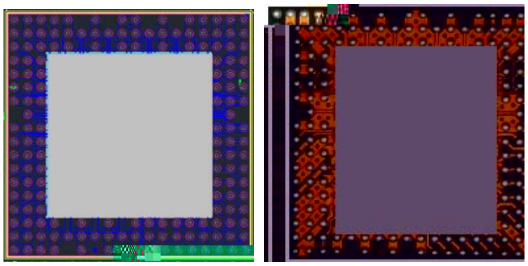

Figure 2. PKG drawing and micrograph of test vehicle of 9x9mm, 0.5mm pitch eWLB.

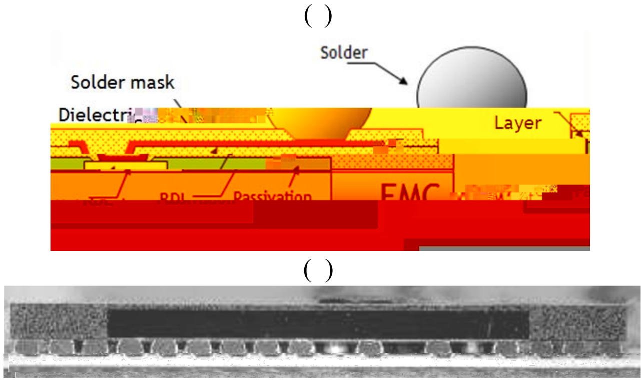

Figure 3. (a) stackup drawing of eWLB and (b) micrograph of cross-section of test vehicle as shown Table 1.

Component Level Reliability

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Test	Q100 Test Condition	Test Conditions
PC Pre-Cond	JEDEC J-STD-020	MSL1 24h bake @ 125°C 168h @ @ 85C/85%RH Reflow simulation (3times) with Lead free profile Tmax=260°C
THB Temp Humidity Bias	JESD22-A101/A110	Ta=85°C, 85%RH 1000h with bias
AC Auto-clave	JESD22-A102/A118	P=2.08atm Ta=121°C, 96h
TC Temp. Cycling	JESD22-A104	Ta = -55/+150°C 1000 cycles
PTC, Power Temperature Cycle	JESD22-A105	Ta = -50/+150°C 1000 cycles
HTSL, High Temp. Storage Life	JESD22-A103	Ta=150°C 1000h
THS, Temp Humidity Storage	JESD22-A101	Ta=85°C, 85%RH 1000h without bias
HAST Highly Accelerated	JESD22-A102/A118	130°C / 85% RH, no bias, 96hrs

Board Level Reliability

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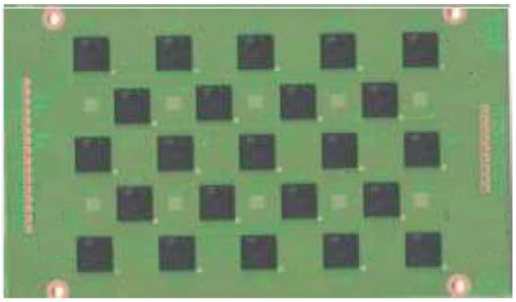

Figure 4. Micrograph of PCB for board level reliability with surface mounted eWLB packages.

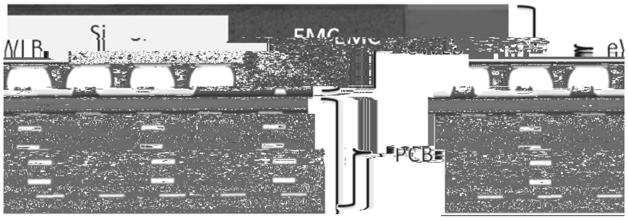

Figure 5. Micrograph of eWLB mounted PCB for board level reliability test.

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1. NSMD board pads showed improved TCoB performance versus SMD ones in all DOE legs.
2. Larger solder mask opening was effective to improve results for the NSMD pad.
3. Thicker Cu RDL showed 15~20% improvement in TCoB test.
4. UBM did not effectively improve TCoB in this study, but is leading to big change in failure distribution. Need to further investigate and understand this behavior and failure mechanism(s).
5. With UBM and a new solder alloy B, it increased TCoB in NSMD pad.

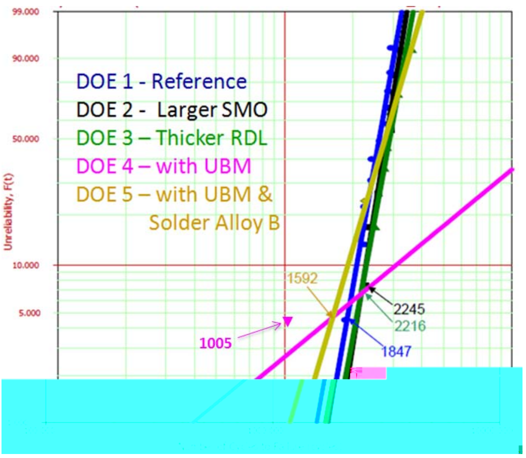

Figure 6. DOE study result : Weibull plot of TCoB reliability test with NSMD PCB. Each no. indicates the first failure cycle in each DOE studies.

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		First Failure Cycles	
		SMD	NSMD
DOE1	Reference	1452	1847
DOE2	Larger solder mask opening	1388	2245
DOE3	Thicker RDL	1763	2216
DOE4	With UBM+RDL	964	1005
[illegible]	With UBM and Solder [illegible]	[illegible]	[illegible]

Failure Analysis of Solder Joint Reliability

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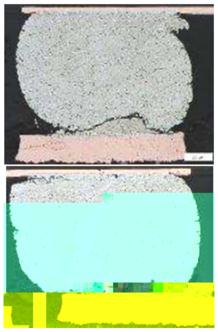
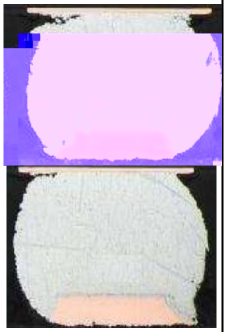
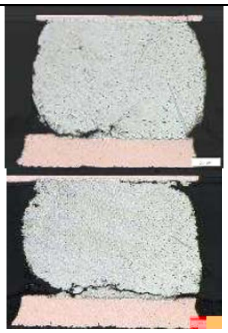
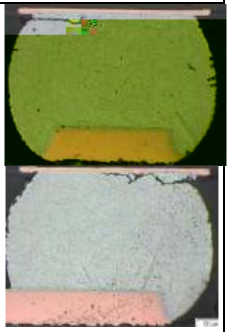
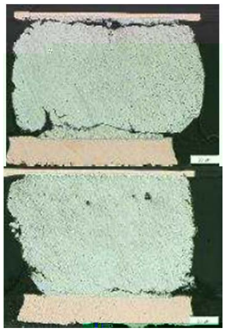
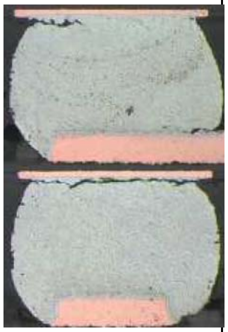
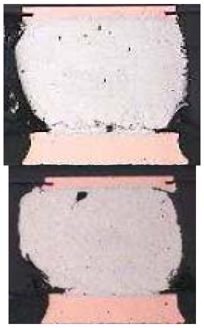
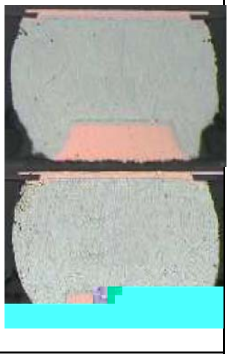
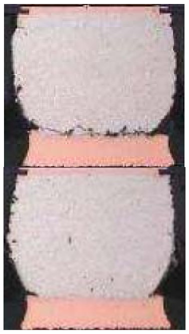
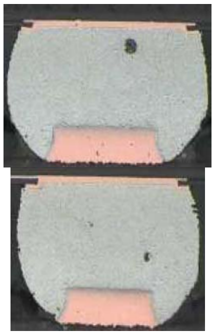
	SMD	NSMD
1		
2		
3		
4		
5		

Figure 7. Optical micrographs of failure of DOE 1~5 samples.

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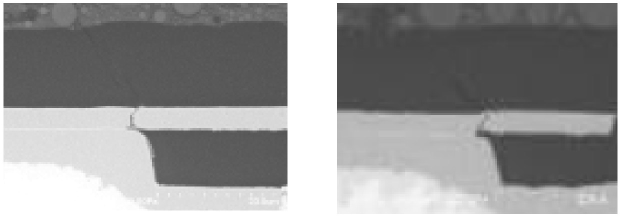
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Figure 8 . SEM micrographs of failure of DOE 4 (with UBM & NSMD)

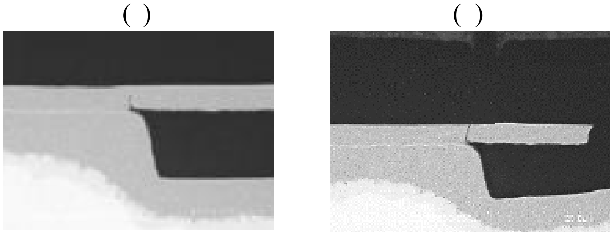

Figure 9. SEM micrographs of failure of DOE 5 (with UBM and solder alloy B & NSMD)

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