AEC-Q006 Rev. B

AEC Reliability Workshop Europe 2025
October 8th - 9th, 2025

BACKGROUND

- AEC-Q006 became a true success story by turning Cu wire from a subject of risk assessments into the reliable automotive state of the art interconnect technology

- The huge number of AEC-Q006 based qualifications created a mature knowledge in the industry about the relevant failure mechanisms and how to observe the level of degradation

- At the same time hundreds of successful qualifications and resulting low failure rates create confidence in the use of Cu wire in the automotive industry.

- AEC-Q006 Rev. B is the natural evolutionary step forward out of these learnings. It reflects 7 years of learning of the industry in using the Q006 qualification methodology to release Cu wire packages.

- The result is a procedure which achieves an efficient Cu wire qualification without any reduced robustness margin or loss of transparency for the user compared to Rev. A.

OVERVIEW – Changes of Rev. B

Besides many smaller updates that result form that learnings there are several main changes which include:

- Rephrased grandfather clause: clarification of boundary conditions
- Clarification on qualification of changes
- Update on technology family qualification requirements
  - Focus on stitch for different lead frame
  - Introduction of 4 lot qualification for copied exactly assembly sites
  - Limitation of delta qualification to TC for smaller dies than reference product
- Full revision of the qualification test plan
  - Move PTC back to product qualification
  - Provide two possible qualification options that ensure margin either by physical analysis requirements after 1x stress or by extended stress to 2x. ATE pass is mandatory in both cases.

Rev. B Qualification Plan

- Two basic options are proposed to qualify a Cu wire technology family according to AEC-Q006revB.

- Option 1: 1x stress duration (based on AEC-Q100/101 requirements) followed by ATE (test temperature requirements as per AEC-Q100/101) AND analytical.
  - Analytical tests must prove to meet minimum requirements.*
  - If this is not the case a risk mitigation by executing 2x stress duration is mandatory.

- Option 2: 2x stress duration (based on AEC-Q100/101 requirements) followed by ATE (test temperature requirements as per AEC-Q100/101).

- This document provides data to support that
  – 1x stress duration for HTSL, HAST/THB and TC, plus meeting criteria for the analytical tests after 1x is able to predict to 2x stress performance
  – PTC per AEC-Q100 is sufficiently covering Cu-wired devices

OVERVIEW

Sequence #	Qualification Step / Stress Test	TC	HAST/THB	PTC	HTSL
1	Initial sampling	Sample sizes as required			
2	CSAM @ T0 (1)	Sample sizes as required			
3	Preconditioning to MSLx	3x77	3x77	1x45	---
4	CSAM after PC (1)	3x22	3x22	1x22	---
5	ATE Test	3x77	3x77	1x45	3x45
6	Stress 1X	3x77	3x77	1x45	3x45
7	ATE Test	3x77	3x77	1x45	3x45
8	CSAM post-1X stress (1,5)	3x22	3x22 (6)	---	---
9a	Ball + Stitch/Wedge pull	3x3 (4,7)	3x3 (4,7)	---	---
9b	Ball shear	3x3 (4,7)	3x3 (4,7)	---	---
10	Cross-section	3x1 (7)	3x1 (7)	---	3x1
11	Stress 2X	3x70 (2)	3x70	1x45	3x44
12	ATE Test	3x70 (2,3)	3x70 (3)	1x45 (3)	3x44 (3)
13	CSAM post-2X stress (1)	3x22 (2)	3x22	---	---
14a	Ball + Stitch/Wedge pull	3x2 (2,4)	3x2 (4)	---	---
14b	Ball shear	3x2 (2,4)	3x2 (4)	---	---
15	Cross-section	3x1 (2)	3x1	---	3x1

Rev. A

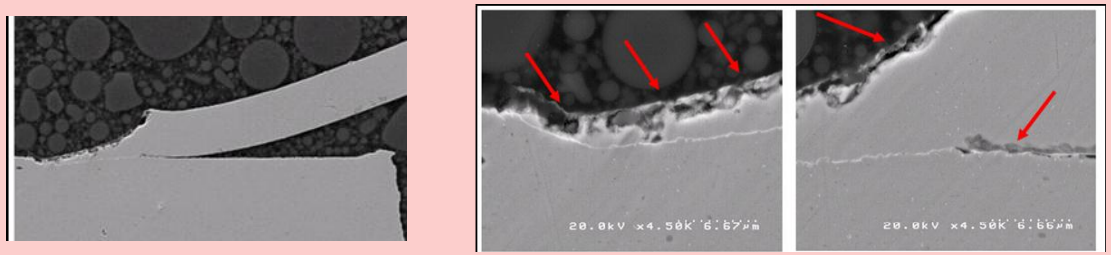
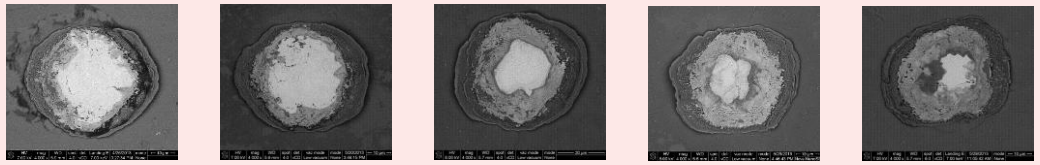
Sequence #	Qualification Step / Stress Test	TC	HAST / THB / H3TRB	HTSL (8)	Option 1	Option 2
1	Initial sampling	Sample sizes as required			●	●
2	AM @ T_0 (1,6)	Sample sizes as required			●	●
3	Preconditioning to MSLx	3x77	3x77	---	●	●
4	AM after PC (1,6)	3x11	--	---	●	●
5	ATE Test	3x77	3x77	3x45	●	●
6	Stress 1X	3x77	3x77	3x45 (4)	●	●
7	ATE Test	3x77	3x77	3x45	●	●
Items 8-11 may be limited to Q100/101 requirements. In this case, continue at item 12.						
8	AM post-1X stress (1)	3x11	--	---	●	
9	SEM inspection (stitch) (5)	3x1	---	---	●	
10a	Ball + Stitch/Wedge pull	3x3 (3)	3x3 (3)	---	●	
10b	Ball shear	3x3 (3)	3x3 (3)	3x3 (3)	●	
11	Cross-section (7)	3x1	3x1	3x1	●	
Continue at item 12 if items 8-11 are not performed or if the criteria according to Section 7.2.1 are not met.						
12	Stress 2X	3x77 (9)	3x77 (9)	3x45 (4,9)	○	●
13	ATE Test	3x77 (2,9)	3x77 (2,9)	3x45 (2,9)	○	●
Items 14-17 are optional, but recommended. If item 13 (ATE Test) is pass, it is recommended but optional to perform items 14-17.						
14	AM post-2X stress (1)					
15	SEM inspection (stitch)					
16a	Ball + Stitch/Wedge pull					
16b	Ball shear					
17	Cross-section (7)					

Lot and sample sizes to be defined on a case by case decision depending on the target of the investigation.

Rev. B

AEC-Q006 Rev. B
HTSL Assessment

HTSL – TARGET FAILURE MECHANISMS

Failure Mechanism	Influencing Factors	Margin Indicators
Corrosion of the wire at stitch  Stitch cross sections of palladium coated wire after HTSL@175°C – Source: TI	Degradation of mold compound components leading to sulfur release Occurs at T >150 °C Does mainly impact coated copper wire (PCC)	No corrosion after 1x stress
Corrosion of Cu-Al intermetallic 24 hrs 48hrs 96hrs 144hrs 240hrs  IMC Coverage after HTSL@200°C with provocation mold compound – Source: NXP	Severity depending on mold compound Function of time and temperature Reduces mechanical stability of ball bond interface	Mechanical stability of ball-pad interface: - Significant high shear forces - No separation between ball and pad

PROPOSED REQUIREMENTS AFTER 1X

The following criteria must be met after 1X stress for HTSL, if 2X stress is not performed:

- WBS Shear Codes: shall not include:
  - Bond lift (Type 1): wire bond separated from bonding surface and no evidence of bond, i.e., IMC formation
  - Cratering (Type 3): residual bonding surface and substrate (bulk) material attached to wire bond

- WBS Force Values:
  - Must be above 0h specification limit
  - Measured minimum individual value of shear force after 1X stress is more than 50% of 0h measured minimum individual value (PASS > 0.5X 0h measured minimum individual value)

- Cross-Section: Any sign of corrosion needs to be assessed using stitch/ wedge pull and force values must be above 0 h specification limit.

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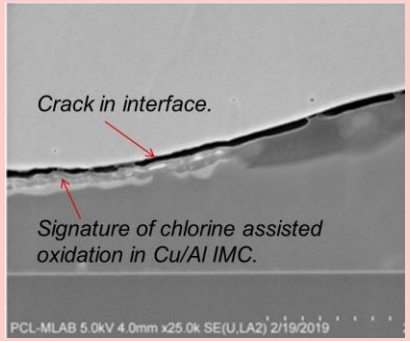
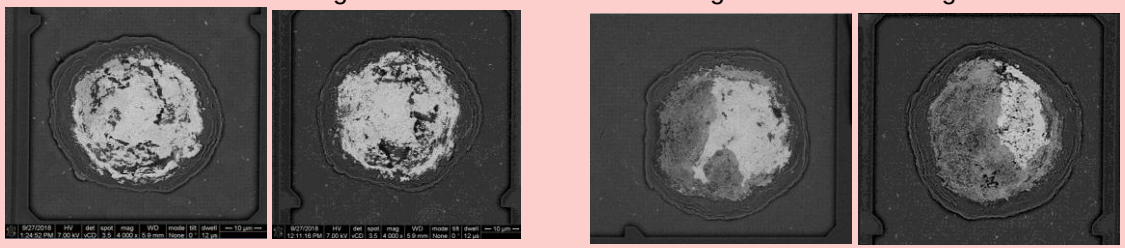
HAST/THB Assessment

HAST/THB – TARGET FAILURE MECHANISMS

Failure Mechanism	Influencing Factors	Margin Indicators
Corrosion at Cu-Al intermetallic  Ball cross sections after biased humidity stress – Source: TI Low bias – no degradation High bias – severe degradation  IMC Coverage after HAST@110°C with low (left) and high (right) bias – Source: NXP	Amount of active chlorine in the background of the mold compound Impacts biased pins only. Higher bias makes degradation more severe. Does not impact copper-copper interconnects.	Mechanical stability of ball-pad interface: - Ball-pad interface may not be the weak link after stress Degree of corrosion after stress.

PROPOSED REQUIREMENTS AFTER 1X

The following criteria must be met after 1X stress for HAST/THB/H3TRB, if 2X stress is not performed:

- WBS Shear Codes: shall not include:
  - Bond lift (Type 1): wire bond separated from bonding surface and no evidence of bond, i.e., IMC formation
  - Cratering (Type 3): residual bonding surface and substrate (bulk) material attached to wire bond

- WBP Pull Codes: shall only include
  - Wire breaks in any point of the wire

- Cross-Section: any sign of corrosion needs to be assessed

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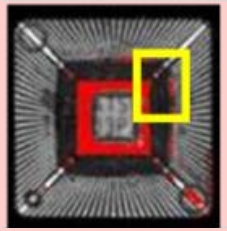
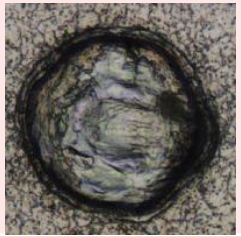
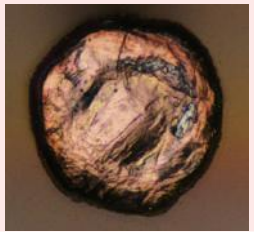
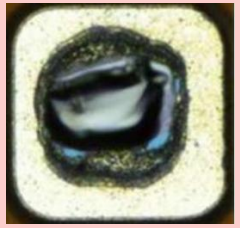
TC Assessment

TC – TARGET FAILURE MECHANISMS

Failure Mechanism	Influencing Factors	Margin Indicators
Stitch /wedge fatigue in presence of delamination   Wedge fatigue linked to lead delamination – Source: TI	Material selection (mold compound, lead surface) Package geometry	No lead delamination after 1x stress No heel cracks after 1x stress
Ball-pad interface fatigue   Lifted ball bond after 1x stress showing insufficient IMC coverage – Source: Infineon	Insufficient IMC coverage	Mechanical stability of ball-pad interface: • Ball-pad interface may not be the weak link after stress
Pad delamination / Cratering  Cratering after WBP– Source: Infineon	Overbonding Non robust pad design	Mechanical stability of pad stack and below: - BeoL stack may not be the weak link in any case

PROPOSED REQUIREMENTS AFTER 1X

The following criteria must be met after 1X stress for TC, if 2Xstress is not performed:

- AM: no delamination allowed at 1st and 2nd bond area and at active side of the die corners

- SEM inspection: no heel cracks

- WBS Shear Codes: shall not include:
  - Bond lift (Type 1): wire bond separated from bonding surface and no evidence of bond, i.e., IMC formation
  - Cratering (Type 3): residual bonding surface and substrate (bulk) material attached to wire bond
- WBS Force Values: must be above 0h specification limit

- WBP Pull Codes: for 1st and 2nd bond pull shall only include:
  - Wire breaks in any point of the wire
- WBP force values must be above 0h specification limit

- Cross-Section: no cracks in BEoL stack for bond over active area

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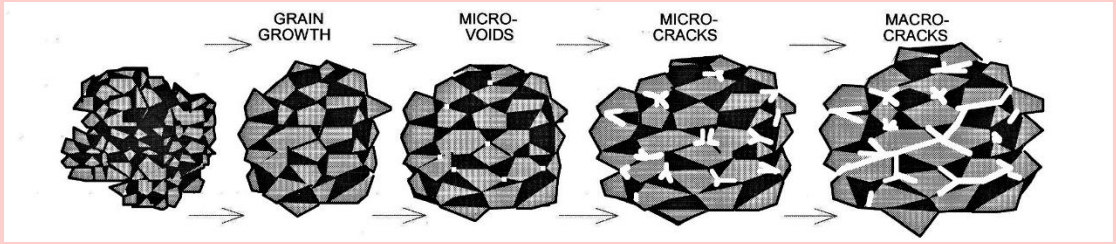
PTC/IOL Relevance

PTC/IOL – TARGET FAILURE MECHANISMS

Failure Mechanism	Influencing Factors	Margin Indicators
Die attach degradation  Visualization of SnPb die attach degradation under PTC conditions	Die attach technology Power dissipation and ramp rates Thermal crowding	No suitable indicator for Cu wire bond reliability

ASSESSMENT RESULTS

Typically the target failure mechanisms of PTC/IOL result from temperature gradients across the chip.

The stress on the Cu wire system is less than that resulting from TC.

No team member of the task group was able to refer to a case were PTC/IOL provided additional information, i. e. no failures occurring exclusively in PTC/IOL with an intrinsic root cause. This observation is in line with the physics of failure perspective.

Result of the team assessment:

- Do PTC/IOL within AEC-Q100/101 qualification to address specific failure mechanisms
- Address thermomechanical driven failure mechanisms of the Cu wire system only by TC (no redundant test)

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Ongoing Ballot

Ballots and Release of AEC-Q006 Rev. B

Stakeholder feedback prior to ballot:

- Based on the AEC Charter the draft version has been shared European and US OEMs in the role of a consultant (according to section 1.6.1 of the AEC TC Charter) within the AEC-Q006 task group.
- Their overall feedback was positive, the approach of a more efficient qualification was generally apricated and no major objections came up.

1st ballot due date May 24th, 2024:

- 111 questions and comments collected during 1st ballot
- All comments have been reviewed and partially integrated in new draft
- Resulting changes make 2nd ballot necessary.

2nd ballot due date April 9th, 2025

- No change in basic new concept of Q006 like presented at the AEC RW 2024
- Ballot passed with 100 % acceptance

Final release June 30th, 2025

Summary

- AEC-Q006 Rev. B has been released and published on the website
- Core item: Two options to secure margin - Physical analysis and verification of level of degradation or extended stress
- New procedure allows streamlining of qualification efforts while keeping the level of reliability

Any further questions?