AEC-Q104 FAILURE MECHANISM BASED STRESS TEST QUALIFICATION FOR MULTICHIP MODULES (MCM) IN AUTOMOTIVE APPLICATIONS

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AEC-Q104

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- AEC-Q104 Revision A Summary
- AEC-Q104 Task Team Members
- Added Light Emitting Diodes (LEDs) AEC-Q102 and Micro Electro-Mechanical System (MEMS) Q103x interactions
  - Qualification test method options in the MCM decision flow diagram (Figure 2)
- Updated AEC-Q104 Test Diagram
- Update Test Methods (Table 1)
  - Clarification HBM, CDM, DROP, STEP and LTSL test details
  - PCT and Alternate Stress Testing Methodologies (TC)
  - Additional MCM Drop Test method added
- Updated AEC-Q104 Process Change Qualification Guidelines
- AEC Q104 Future Tasks

AEC-Q104 Revision A Update Overview

The AEC-Q104 Multichip Module MCM document and QTP revision A is pending release targeting April 2025.

AEC-Q104 rev A improves on the original:

- ✓ Added Discrete Optoelectronic Semiconductors such Light Emitting Diodes (LEDs) AEC-Q102 MCM interactions
- ✓ Added Micro Electro-Mechanical System (MEMS) AEC-Q103x MCM interactions
- ✓ Updated MCM Qualification Plan flow diagram
- ✓ Improved test flow diagram consist with other AEC documents
- ✓ Updated specific test definitions and acceptance details
- ✓ Updated Process Change Qualification Guidelines (change matrix)

AEC-Q104 Task Team Members

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Gary Fisher	Gentex (previous team member)
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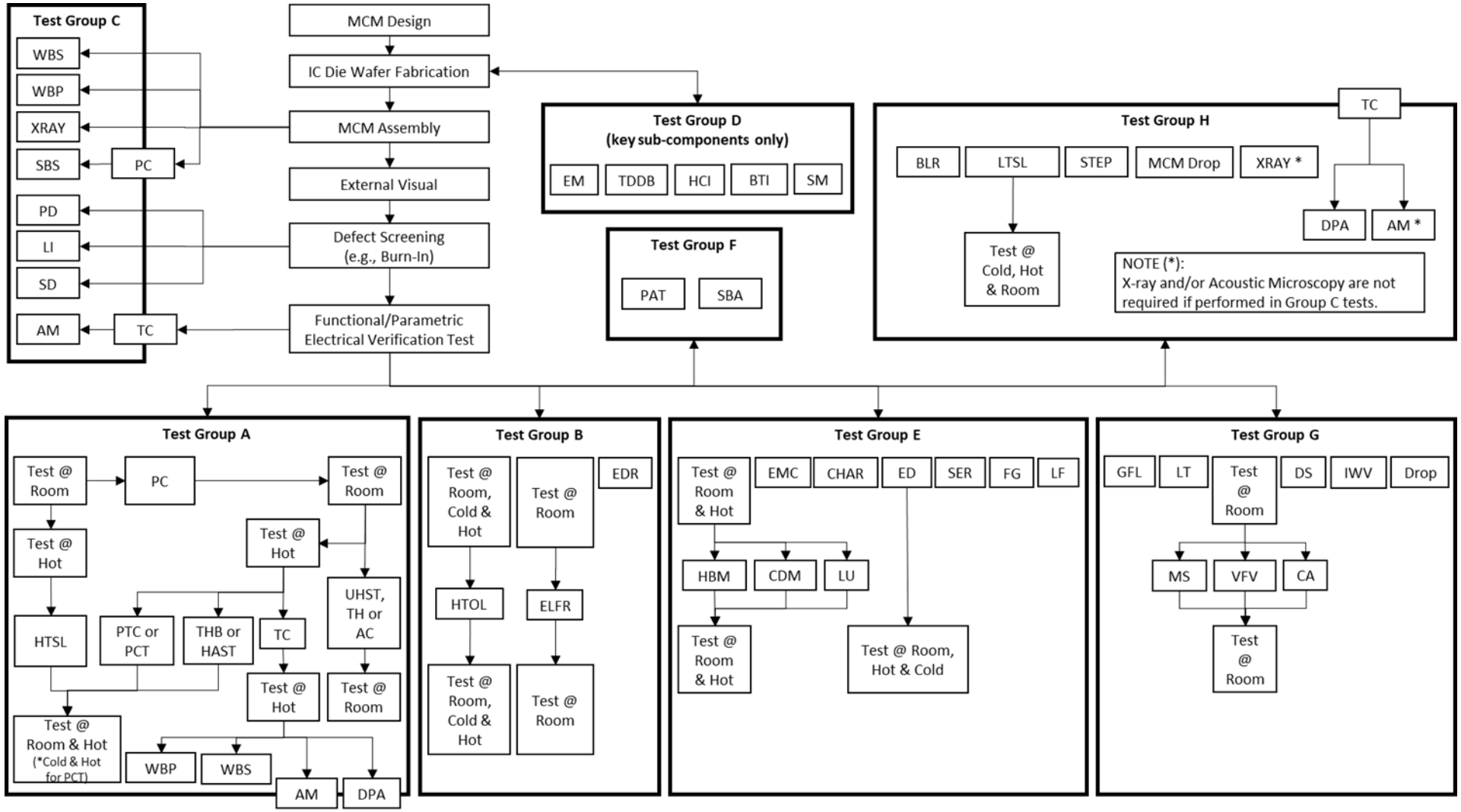
Thank you for your valuable contributions

Light Emitting Diodes (LEDs) AEC-Q102 and Micro Electro-Mechanical System (MEMS) Q103x interactions

- Scope added AEC-Q102 and AEC-Q103x in scope, cross references, applicability
- Added AEC-Q102-003 for MCM specific LED requirements
- Updated the qualification test method options in the MCM decision flow diagram (Figure 2) to include pertinent specific function qualification test such as LED or MEMs
- Updated Definition of Generic Data to include AEC-Q102 and AEC-Q103X requirements.

Updated AEC-Q104 Test Diagram Consistent with Other AEC Documents



Test Methods (Table 1) Updates continued

- ✓ Electrostatic Discharge Human Body Model (HBM) ESD criteria consistent with AEC-Q100
- ✓ Electrostatic Discharge Charged Device Model (CDM) ESD criteria consistent with AEC-Q100
- ✓ MCM Drop Test details clarified: see new slide
  - ✓ Use JEDEC JESD22-B110 or JEDEC JESD22-B111 based on MCM construction and use conditions
- ✓ Start Up and Temperature Steps (STEP) test pictorial and description
- ✓ Clarified Low Temperature Storage (LTSL) stress at minimum storage temperature

Test Methods (Table 1) Updates continued

- ✓ Additional MCM Drop Test method added
  - ✓ In the new Revision: Use JEDEC JESD22-B110 (Test H4A) or alternate JEDEC JESD22-B111 (Test H4B) based on MCM construction and use conditions. The supplier can choose the applicable method.
  - ✓ When AEC-Q104 was first introduced, MCM Drop Test (H4) required 5 MCMs to be tested to Condition B of JESD22-B110 with no failures. This test condition is typically used for solder joint robustness characterization of encapsulated devices utilizing the standardized test JESD22-B111.
  - ✓ For this revision of AEC-Q104 it was decided to add an optional Drop Test for MCMs with exposed solder joints and/or wire bonds. The test method used is JESD22-B111 for the MCM. Mounting of the MCM on a Daisy Chain Board is preferred for this test. The testing would result in an initial report and a report after 62.3 % failure cycles for characterization by Weibull analysis.

PCT and Alternate Stress Testing Methodologies (TC)

Power Temperature Cycling (PTC) is a stress of repetitive and rapid changes in power dissipation in conjunction with temperature cycling. It accelerates the stresses on all bonds and interfaces with thermo-mechanical stress from internal heating from repeated turn on and off and external heating from temperature cycling.
There are many challenges to Power Temperature Cycling for MCMs and integrated circuits, such as:

- ✓ Biasing the MCM (or even the relevant sub-component) may only result in toggling between low power states (such as between “off” and STANDBY) that do not represent the high power state experienced in operation.
- ✓ Even with a POWER DEVICE or other large power dissipation sub-component inside the MCM, it may not be directly accessible in an MCM to allow it to be biased or to be biased quickly when starting from an off state.
- ✓ If the device or a sub-component needs to perform operations at high speed to create the large change in power dissipation, a high speed test platform will likely be necessary and typically precludes the platform from being a fast enough temperature cycle chamber to cycle both power and temperature.

PCT and Alternate Stress Testing Methodologies (PTC)

The Power Cycling Test (PCT) has been added to evaluate the stresses resulting from non-uniform temperature gradients within the MCM during power cycles without the challenges/limitations from concurrently cycling ambient temperature. In the Power Cycling Test, the power cycling is performed while the ambient test temperature remains constant. See JESD22-A122 option for Constant Heat/Cooling, Variable Power for the concept.

Power Temperature Cycling (PTC) remains an option for stressing MCMs and can be an effective stress for power devices. But, for MCMs that cannot reach high power states with merely bias or low speed operation, the addition of a Power Cycling Test (PCT) alternative method provides a non-uniform heating stress option.

The AEC Q104 team would like to collect additional data from suppliers who use this alternate PCT method with MCMs in the future. Please contact Steve Sibrel or Tom Lawler with plans and results as they become available.

Additional AEC-Q104 updates

Updated AEC-Q104 Process Change Qualification Guidelines

- Clarified and added select changes
  - ✓ Substrate materials change and/ or external dimensions
  - ✓ Substrate change affecting module schematic
  - ✓ Change to the processes used in during module assembly
  - ✓ Change to testing platform and/or coverage
  - ✓ Change of product marking process (ink marking only)
- Added pertinent Group H Tests

The AEC-Q104 change quideline is consistent with PCN-Delta-Qualification-Matrix-ZVEI-5.0 – Tab “MCM” (see subsequent slide)

Table 2 Process Change Qualification Guidelines Revision

- **Sample Page**

Table 2: Process Change Qualification Guidelines for the Selection of Tests

A2	Temperature Humidity Bias or HAS	C4	Physical Dimensions	E8	Electromagnetic Compatibility	G8	Internal Water Vapor
A3	Autoclave or Unbiased HAST	C5	Solder Ball Shear	E9	Soft Error Rate	H1	Board Level Reliability
A4	Temperature Cycling	C6	Lead Integrity	E10	Lead (Pb) Free	H2	Low Temperature Storage Life
A5	Power Temperature Cycling	C7	X-ray / CSAM	G1	Mechanical Shock	H3	Start Up and Temperature Steps
A6	High Temperature Storage Life	D1-5	Die Fabrication Reliability Tests	G2	Variable Frequency Vibration	H4	MCM Drop Test
B1	High Temperature Operating Life	E2	Human Body Model ESD	G3	Constant Acceleration	H5	Destructive Physical Analysis
B2	Early Life Failure Rate	E3	Charged Device Model ESD	G4	Gross/Fine Leak	H6	X-ray
B3	NVM Endurance, Data Retention	E4	Latch-up	G5	Mechanical Shock Cavity Device Drop	H7	Acoustic Microscopy
C1	Wire Bond Shear	E5	Electrical Distribution				
C2	Wire Bond Pull	E6	Fault Grading	G6	Lid Torque		
C3	Solderability	E7	Characterization	G7	Die Shear		

Note: A letter or "●" indicates that performance of that stress test should be **considered** for the appropriate process change. Reason for not performing a considered test should be given in the qualification plan or results.

Test #		A2	A3	A4	A5A/B	A6	B1	B2	B3	C1	C2	C3	C4	C5	C6	C7-8	D1-5	E2	E3	E4	E5	E6	E7	E8	E9	E10	G1-3	G4	G5	G6	G7	G8	H1	H2	H3	H4A/B	H5	H6/H7
Test Abbreviation		THB	AC	TC	PTC/PCT	HTSL	HTOL	ELFR	EDR	WBS	WBP	SD	PD	SBS	LI	XRAY/CSAM	DFRT	HBM	CDM	LU	ED	FG	CHAR	EMC	SER	LF	MS/VFV/GA	GFL	DROP	LT	DS	IWV	BLR	LTSL	STEP	MCM DROP	DPA	XRAY/AM
Change Type	**Change Impact**																																				
Any	Including critical characteristics of subcomponent(s) are affected (Note 1)	●	●	●	●	●	●	●	●	D	D	●	●	●	●	●	F	●	●	●	H	●	H	●	K	●	●	●	●	●	L	●	●	●	●	●	●
Substrate materials change and/ or external dimensions	Any	●	●	●	●	●	●	●	●	D	D	●	●	●	●	●	F	●	●	●	H	●	H	●	K	●	●	●	●	●	L	●	●	●	●	●	●
Substrate change affecting module schematic (changes to the internal dimensions and/or schematics)	Any	●	●	●	A		●	●		D	D							●	●	●	H	●	H	●	K						L					●	
Change that adds or subtracts sub-components from the module BOM	Any	●	●	●	A	●	●	●									G	●	●	●	H	●	H	●	K		●				L				●			

AEC Q104 Current and Future Tasks

Prepare for future revisions

- Capture industry new MCM qualification and reliability learnings
  - Bend testing
  - Temperature grading
- Investigate a “simple MCM” exclusion definition
- Define appropriate MCM sequential test requirements based on industry learning and customer requirements
- Update test methods details
- Add MCM specific items to the “Universal CDC” template
- New members are appreciated. Please volunteer if interested.

ANY QUESTIONS ?? Please address to Steve Sibrel and Tom Lawler