MCM Package Development for In-Vehicle Infotainment System

10/23/2014

Terry Kang, Ron Boja & Abraham Yee

Advanced Technology Group

Contents

- In-Vehicle Infotainment System Introduction
- Key Technical Challenges & Solutions
  - Package Design
  - Assembly Process and Material
- Automotive Package Reliability
- Summary

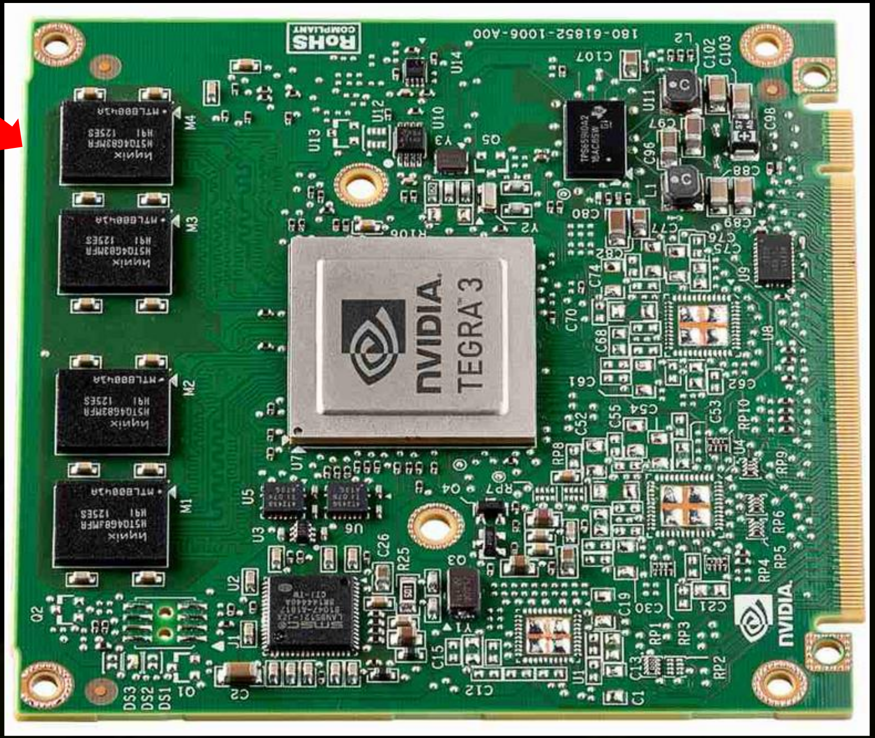
In-Vehicle Infotainment System

Source: NVIDIA Website

In-vehicle infotainment is a integration of hardware devices to provide audio, visual entertainment and automotive navigation system.

NVIDIA's VCM (Visual Computing Module)

Size: 85mm X 85mm



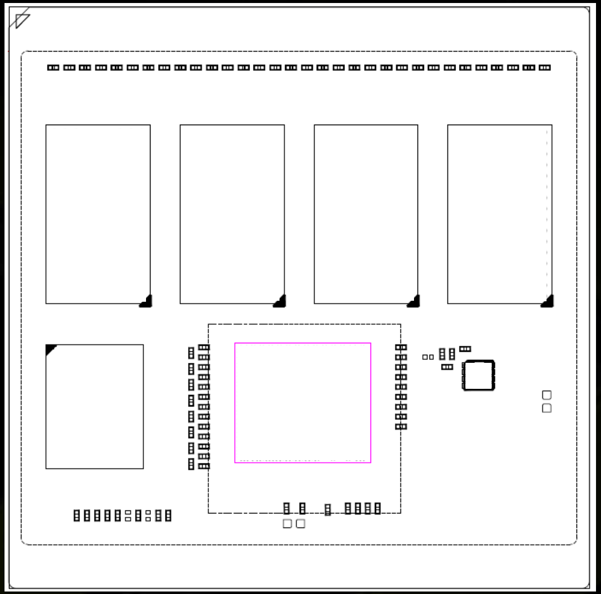
Size: 42.5mm x 42.5mm

Source: NVIDIA Website

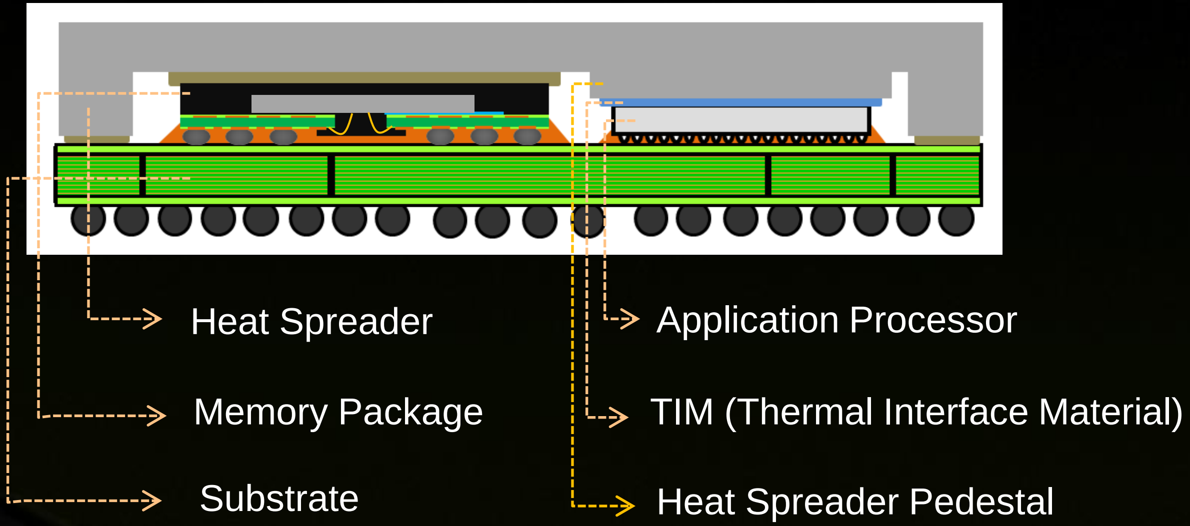
- **Smaller size (75% area reduction)**
- **Higher electrical performance**
- **Lower cost**
- **Wider adoption**

VCM MCM Package Introduction

Top View



Cross Sectional View

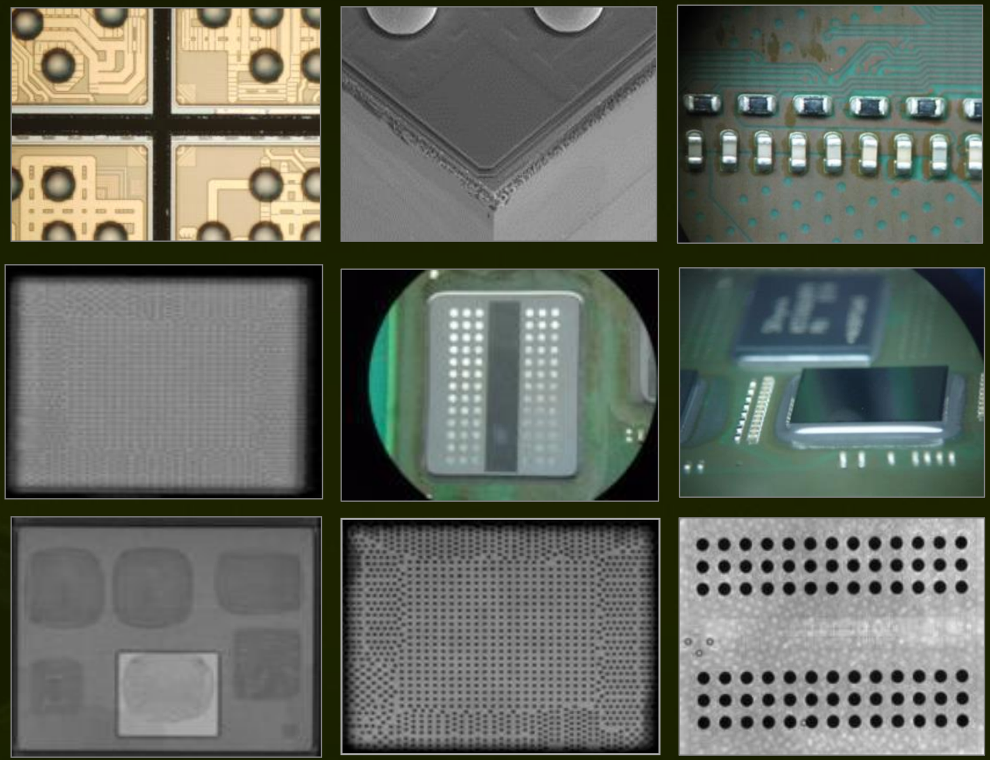


- **42.5mm x 42.5mm FCBGA with lid, 1208 Balls**
- **Integrated with AP, memory, flash, thermal sensor and passives**
- **Heat-spreader with pedestal design**
- **Standard substrate core and build up material**

Assembly Process Flow

- Wafer Saw
- Die, Memory, Passive Attach
- Solder Reflow
- UF Dispense and Cure
- Lid Attach
- Solder Ball Attach

Process Monitoring



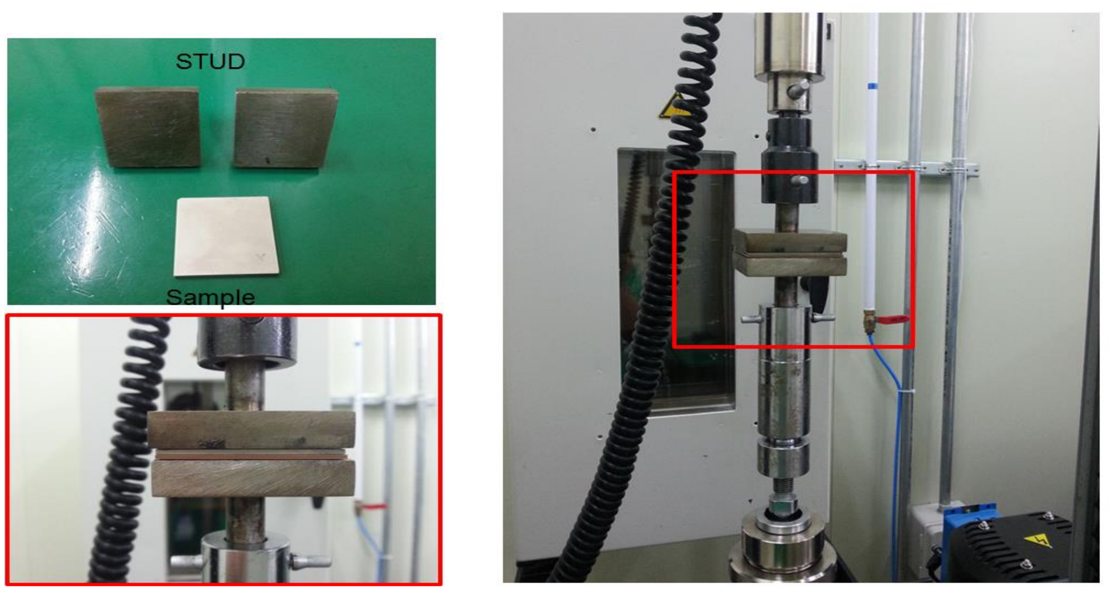
Automotive Requirement > 1.67 Cpk

Lid Adhesion Strength

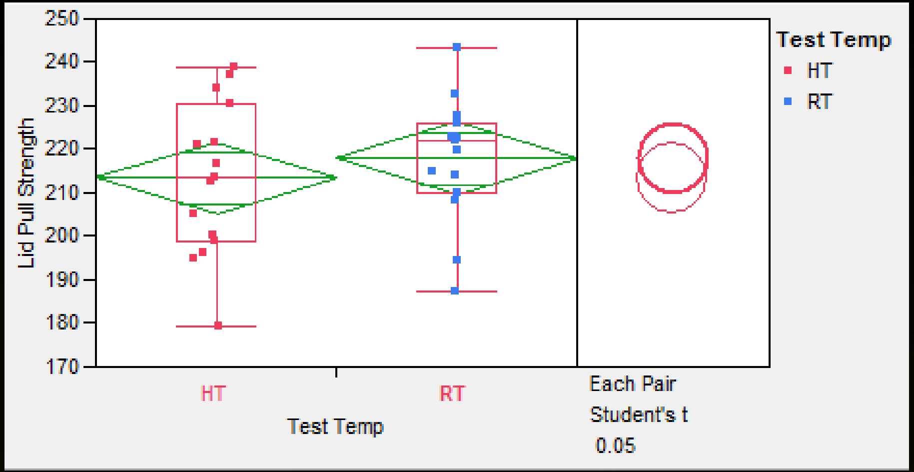
Lid to Substrate Contact Area

	FC BGA			MCM
	A	B	C	VCM
PKG Body (mm2)	45	42.5	42.5	42.5
Lid foot (mm2)	5	5	5	3.5
Lid to Substrate Contact Area (mm2)	**560**	**407**	**380**	**690**
Contact Area vs. PKG Body Ratio	**0.28**	**0.23**	**0.21**	**0.38**

Lid Pull Test Set-up

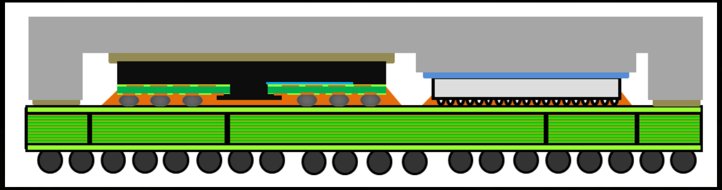


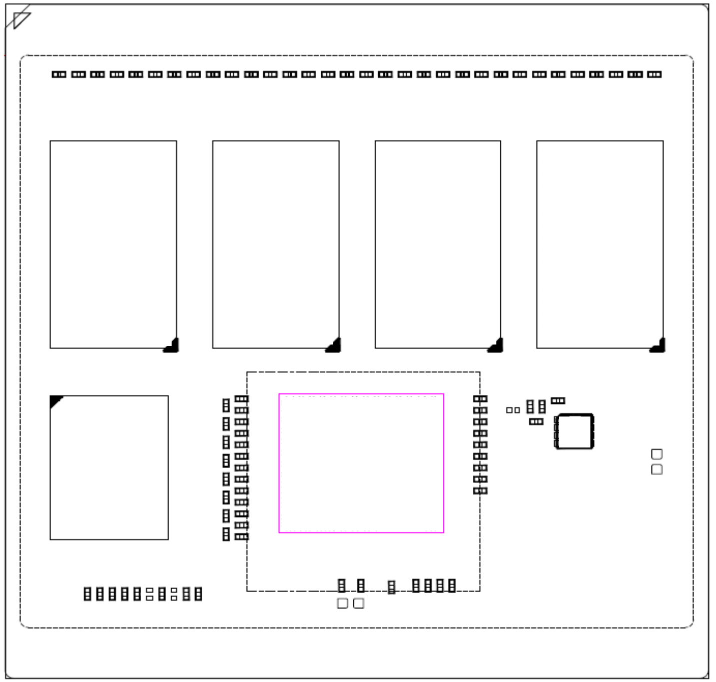
Lid Pull Test Result



- **Lid Pull Adhesion**
  - **Min: 187 Kg (RT), 179 Kg (HT)**
  - **Max: 243 Kg (RT), 238 Kg (HT)**
  - **Ave: 217 Kg (RT), 213 Kg (HT)**
- **Above spec, 145Kg (min)**
- **Cohesive failure**

Lid Tilt and TIM BLT Control

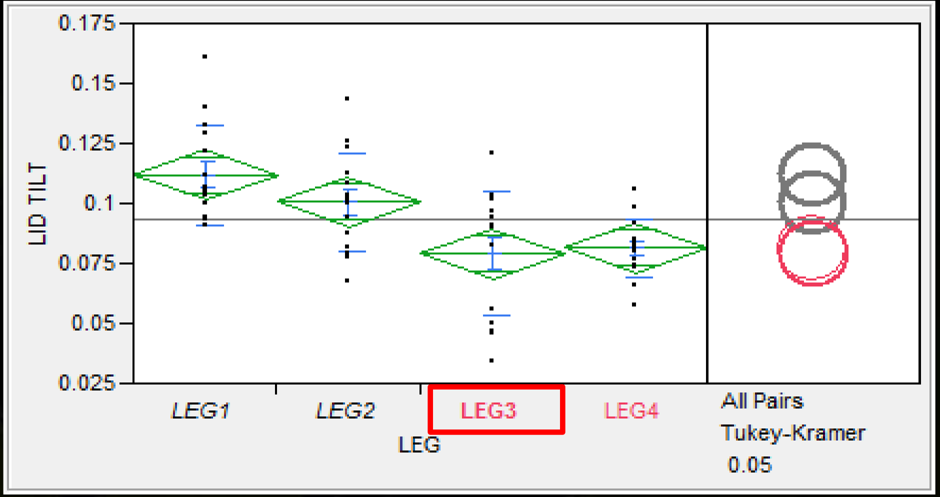




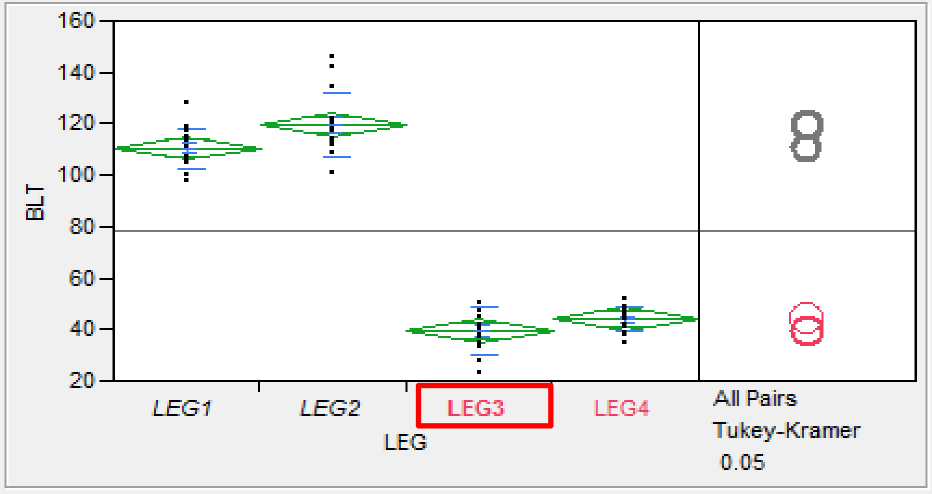
- Technical Challenges
  - Asymmetrical package floor plan
  - Thinner flip chip die thickness than memory package
  - TIM BLT requirement on flip chip die
  - Special lid design
- Solutions
  - Adhesive and TIM volume control
  - Lid foot height control
  - Lid pedestal height optimization

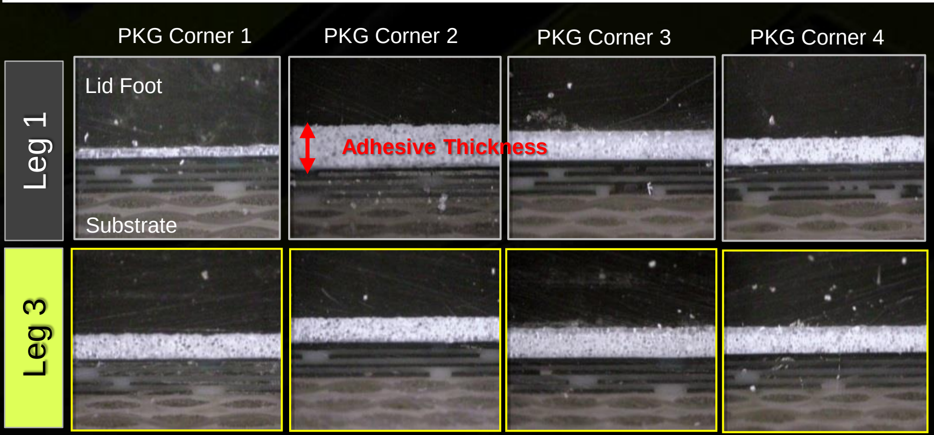
Lid Pedestal Height Optimization

Lid Tilt

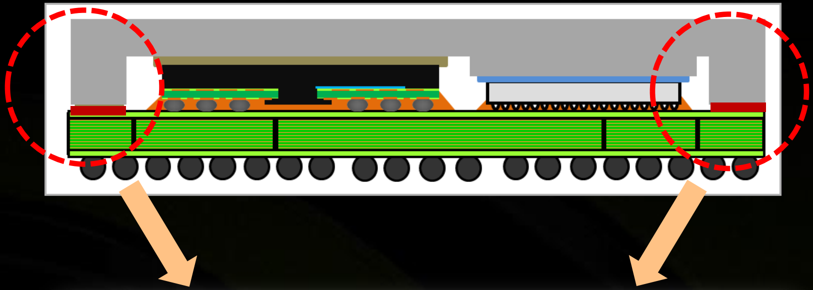


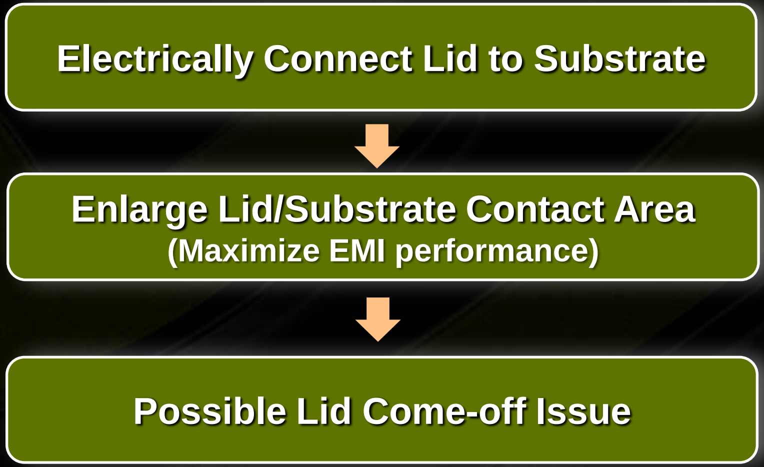
TIM BLT





Lid Ground for EMI Shielding





Electrically Connect Lid to Substrate

Enlarge Lid/Substrate Contact Area
(Maximize EMI performance)

Possible Lid Come-off Issue

- Technical Challenges
  - Poor adhesion of conductive materials
  - Resistivity increase during package reliability test
  - Lid ground pad design on substrate
- Solutions
  - Optimize conductive material properties
    - No significant R increase
    - Good adhesion
  - Select GND pad finish compatible with conductive material
  - Lid ground pad design

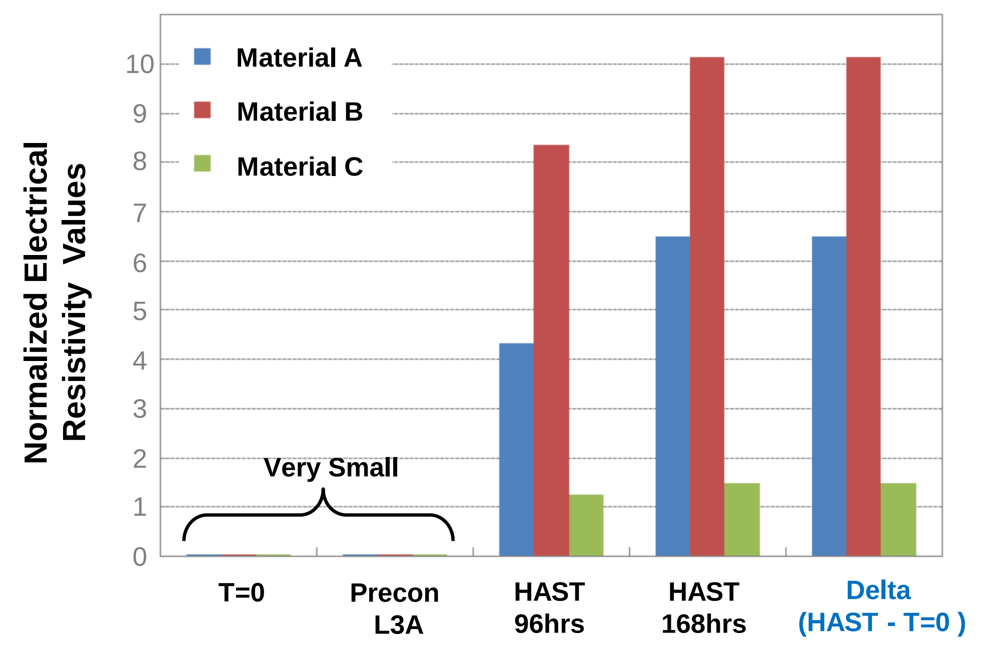
Conductive Material Evaluation

Electrically Conductive Material Candidates

	A	B	C
Volume Resistivity	**High**	**Low**	**Medium**
Tg (C)	**Medium**	**Low**	**High**
C.T.E (ppm)	**Low**	**High**	**Medium**

- **No significant resistivity increase after T=0 and Precon**
- **High resistivity increase after HAST**
- **No correlation between initial material electrical resistivity and post package reliability test**

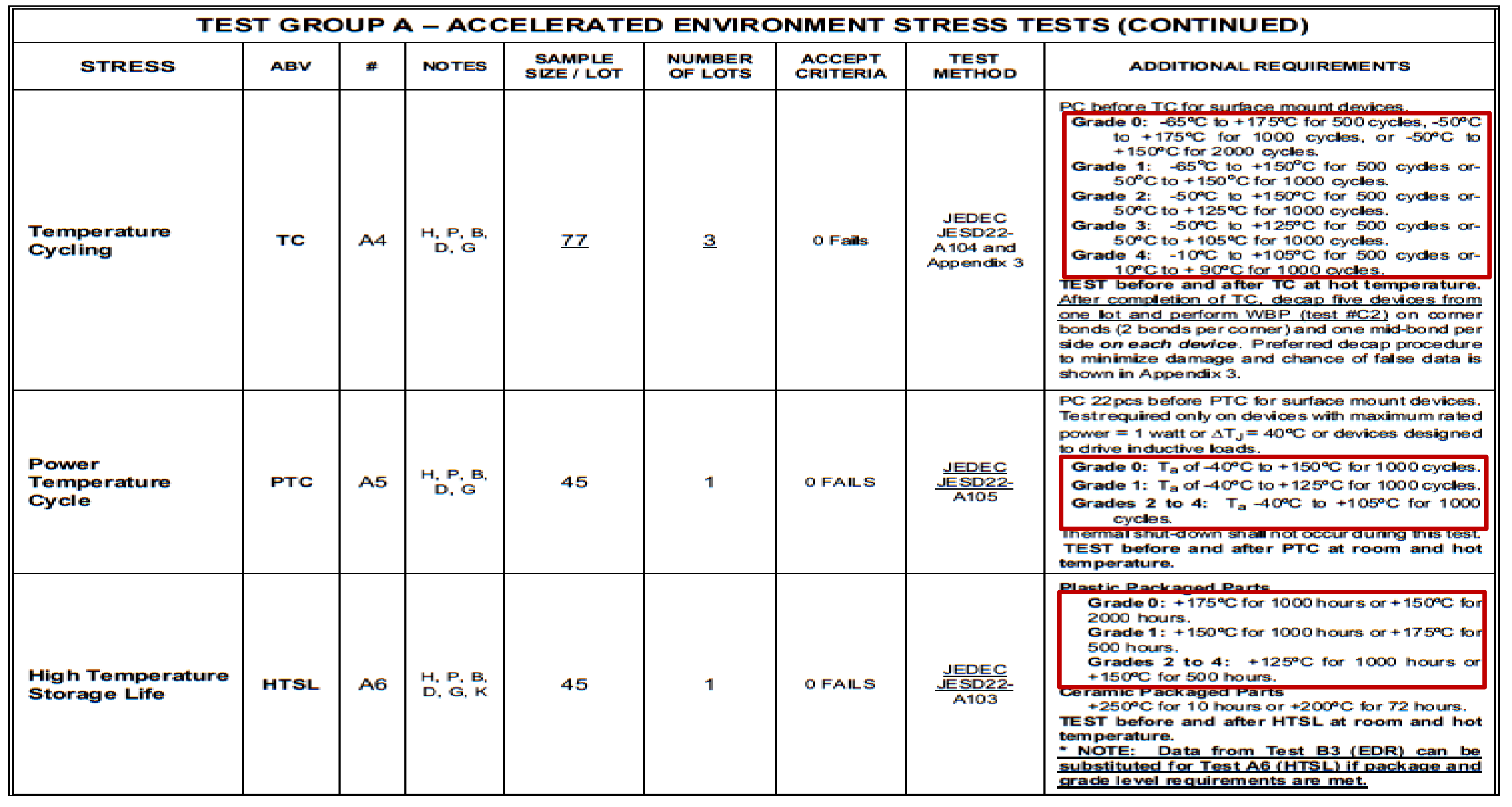
Resistivity Measurement Results



AEC-Q100

- Automotive Electronics Council - Qualification 100
  (Stress Test Qualification for Integrated Circuits)
- Purpose
  To determine that a device is capable of passing the specified stress tests and thus can be expected to give a certain level of quality/reliability in the automotive application
- Definition of Part Operating Temperature Grade
  - Grade 0: -40°C to +150°C
  - Grade 1: -40°C to +125°C
  - Grade 2: -40°C to +105°C
  - Grade 3: -40°C to +85°C
  - Grade 4: 0°C to +70°C

Example of AEC-Q100 Tests



TEST GROUP A – ACCELERATED ENVIRONMENT STRESS TESTS (CONTINUED)								
STRESS	**ABV**	**#**	**NOTES**	**SAMPLE SIZE / LOT**	**NUMBER OF LOTS**	**ACCEPT CRITERIA**	**TEST METHOD**	**ADDITIONAL REQUIREMENTS**
Temperature Cycling	**TC**	A4	H, P, B, D, G	77	3	0 Fails	JEDEC JESD22-A104 and Appendix 3	PC before TC for surface mount devices. **Grade 0:** -65°C to +175°C for 500 cycles, -50°C to +175°C for 1000 cycles, or -50°C to +150°C for 2000 cycles. **Grade 1:** -65°C to +150°C for 500 cycles or -50°C to +150°C for 1000 cycles. **Grade 2:** -50°C to +150°C for 500 cycles or -50°C to +125°C for 1000 cycles. **Grade 3:** -50°C to +125°C for 500 cycles or -50°C to +105°C for 1000 cycles. **Grade 4:** -10°C to +105°C for 500 cycles or -10°C to + 90°C for 1000 cycles. **TEST before and after TC at hot temperature.** After completion of TC, decap five devices from one lot and perform WBP (test #C2) on corner bonds (2 bonds per corner) and one mid-bond per side *on each device*. Preferred decap procedure to minimize damage and chance of false data is shown in Appendix 3.
Power Temperature Cycle	**PTC**	A5	H, P, B, D, G	45	1	0 FAILS	JEDEC JESD22-A105	PC 22pcs before PTC for surface mount devices. Test required only on devices with maximum rated power = 1 watt or ΔT_J = 40°C or devices designed to drive inductive loads. **Grade 0:** T_a of -40°C to +150°C for 1000 cycles. **Grade 1:** T_a of -40°C to +125°C for 1000 cycles. **Grades 2 to 4:** T_a -40°C to +105°C for 1000 cycles. Thermal shut-down shall not occur during this test. **TEST before and after PTC at room and hot temperature.**
High Temperature Storage Life	**HTSL**	A6	H, P, B, D, G, K	45	1	0 FAILS	JEDEC JESD22-A103	**Plastic Packaged Parts** **Grade 0:** +175°C for 1000 hours or +150°C for 2000 hours. **Grade 1:** +150°C for 1000 hours or +175°C for 500 hours. **Grades 2 to 4:** +125°C for 1000 hours or +150°C for 500 hours. **Ceramic Packaged Parts** +250°C for 10 hours or +200°C for 72 hours. **TEST before and after HTSL at room and hot temperature.** *** NOTE: Data from Test B3 (EDR) can be substituted for Test A6 (HTSL) if package and grade level requirements are met.**

Source: www.aecouncil.com

Summary

- Package design was optimized to control warpage, lid adhesion, TIM BLT and lid tilt. Package materials were developed and evaluated to achieve high EMI performance
- Extended package reliability tests were performed to ensure reliability margin
- NVIDIA has successfully developed MCM package to meet automotive reliability requirements and electrical/thermal performances