SiPs in Automotive Applications

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Automotive Market

- **Car Sales (Mu)**
  - 2017: 95
  - 2018: 96
  - 2019: 98

  Car sales are flat

- **Auto Semi Sales ($B)**
  - 2017: 37
  - 2018: 41
  - 2019: 44

  Rising electronic content per car is driving semiconductor growth

- **Semi Content per Car (S)**
  - 2017: 389
  - 2018: 427
  - 2019: 448

  Average semi content per car is rising
Largest Growth Applications

**ADAS**

- **$5B** 2018
- **$11B** 2023

Rise of driver assist features and autonomous driving

**Infotainment**

- **$7.4B** 2018
- **$9.3B** 2023

Connected vehicle

**Electrification**

- **$1.6B** 2018
- **$4.3B** 2023

Conversion to hybrid and electric vehicles
Automotive Packaging

- **Body Electronics**: Comfort, HVAC, Lighting
  - BGA, QFN, QFP, SOP
- **Infotainment**: A/V, Center Stack, HUD, Telematics
  - BGA, HZIP, QFN, QFP, SiP, SOP
- **ADAS**: Park Assist, Radar, Blind Spot Detection
  - BGA, WLFO
- **Powertrain**: Engine Control Unit, Fuel Injection
  - HQFP, QFP, Power Module
- **Instrument Cluster**: QFP, SOP
- **Chassis**: Antilock Brakes, Traction Control
  - QFN, QFP
- **EV/HEV**: QFP, SOP
- **MCU, GPU**: LQFP
- **RF/mmWave Transceivers**: fCSP
- **Processor + Memory**: SiP
- **Sensors**: Overmolded, Exposed Die
- **Accelerated adoption of Advanced Packaging**

**Power**
- Dual LF

**MLF®**
Automotive Products

- **Long lifecycle products**
- **Built on long lifecycle silicon nodes and packages**
- **Supported by stable, long-term suppliers**
The Multiplier Effect

Component: Too High 1 ppm → 250 ppm → 10,000 ppm (1.00%)

Target: ~0 ppm → 10 ppm → 400 ppm (0.04%)

System: 250 Components → 40 Systems → Car
Dealing with the Multiplier Effect

Design  Integration  Redundancy  Screening
Meeting Automotive Requirements

- **Quality Systems**
  - Based on automotive standards

- **Process Flow & Controls**
  - Stringent process flow and controls
  - Dedicated lines, equipment and people

- **Capability**
  - Automotive-grade facilities
  - Long-term stability
### Automotive Quality Requirement: QMS

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<th>QMS</th>
<th>Non-Automotive</th>
<th>Automotive</th>
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Quality Management System (Automotive)  
Quality Management System (Overall Industry)  
Transition by 2018
Typical Automotive Assembly Process Flow

1. **Wafer Incoming AOI Inspection** → **Wafer Mount** → **Laser Groove** → **Dicing Saw/Clean** → **2nd Opt AOI Inspection** → **2nd Opt QA Gate** → **Substrate Prebake**
2. **Chip/Component Attach & Reflow** → **Flux Clean** → **Component AOI Inspection** → **Prebake** → **Plasma Clean** → **Underfill Dispense** → **Underfill Cure**
3. **CSAM Inspection** → **IR Scope Inspection, Sampling** → **Internal Visual Inspection** → **Internal Visual Inspection Gate** → **Heat Spreader Attach** → **Heat Spreader Attach Cure** → **Laser Mark**
4. **Solder Ball Attach + Land Side Component Attach (Optional)** → **Flux Clean** → **100% Open/Short Test** → **100% Dimensional Inspection** → **Final Visual Inspection** → **Final Visual Inspection Gate** → **Dry Packing/Packing**
Product Quality Starts with Design

- Capture learning from prior experiences
- Develop automotive-specific design rules
- Study package & material interactions
- Use the standard BOM
- Design for process Cpk >1.67
Automotive SiP HVM Example

Zero-Defect Escapes

- 99.96% assembly yield
- No rework
- Continuous improvement
Other Considerations for Automotive SiP

Automotive Qualified Components
▶ Q200 for passives

Die and Component Traceability
▶ Track die location on wafer
▶ Track component details (supplier lot #, reel position)
Automotive Factory Setup

- Quality Indices Monitoring
- Certified Operators
- Designated Equipment
- Automation
- Cleaner Environment
- Incoming Material Inspection
AEC Q-100 Qualification Test Flow

AEC-Q100 ambient operating temperature ranges

- 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 to 70°C)

Qualification tests specifically related to package and assembly
AEC Q-100 Test Group A

Precondition Level 1
85°C, 85% RH, 168 hours
3x Reflow, 260°C

Grade 0:
-55°C to 150°C for 2000 cyc
Grade 1:
-55°C to 150°C for 1000 cyc

Unbiased HAST
(77 units x 3 lots)
130°C/85% RH for 96 hours, or
110°C/85% RH for 264 hours.

High Temp Storage Life (45 units)
Grade 0: 175°C/1000 hours, 150°C/2000 hours
Grade 1: 150°C/1000 hours, 175°C/500 hours

Temperature Cycling
(77 units x 3 lots)
Grade 0: -55°C to 150°C for 2000 cyc
Grade 1: -55°C to 150°C for 1000 cyc

JeDEC J-STD-020, JESD22-A113

Precondition Level 2
85°C, 60% RH, 168 hours

Precondition Level 3
30°C, 60% RH, 192 hours

Test @ Room
Test @ Hot
SAT
Test @ Hot
Test @ Room

Test @ Room & Hot
Test @ Hot
Wirebond Pull
Test @ Room
Enabling Automotive Supply Chain

- Supplier qualification minimum requirements
  - ISO9001:2015 certified & IATF16949 compliant
    - Encouraging IATF16949 certification
    - 72% of suppliers certified or to be certified
  - VDA6.3 process audit (Grade A, 90%)

- Intensive supplier quality & process control
  - Supplier outgoing control by commodity
    - FCBGA: 100% AOI + 4 wire test + 100% AFVI + 100% FVI
  - Amkor incoming eCoC control with SPC
    - Real time & Statistical incoming quality control
  - Robust quality probation and release process
Automotive Infotainment SiP

1st Gen Device in Card Configuration

50% Area reduction component count reduction better electrical performance

2nd Gen Device in BGA Configuration
LiDAR Sensors

- Package requirements (detector)
  - Multi-dies integration
  - Anti-reflectivity coating glass
  - Particle reduction
  - Good thermal performance
  - High reliability requirement
  - Hermetic seal (option)
77GHz Radar Module

- Power
  - QFN
  - SOIC
- CAN Transceiver
  - CABGA
- 32-Bit MCU
- VCO
  - 77GHz Transmit
- 77GHz Receive
  - Antenna Layer
  - Silicon

Integration
WLFO Antenna in Package
Turnkey Capabilities

- Fast feedback loop
- Reduced shipping and handling
- Reduced cycle time and WIP
Automotive Test Process Flow – A* Customer

1. Incoming Inspection
2. Final Test 1 (Hot Temp: 105°C)
3. Final Test 2 (Room Temp: 25°C)
4. Final Test 3 (Cold Temp: -40°C)
5. Final Test 4 (Post Burn-In) (Hot Temp: 105°C)
6. Final Test 5 (Post Burn-In) (Hot Temp: 105°C)
7. Burn-in Test 1 (Stress Test: 85°C & High Voltage)
8. Burn-in Test 2 (Stress Test: 85°C & High Voltage)
9. SLT (System Level Test) (Ambient)
10. Final Test 6 (Post Fuse Blown) (Room Temp: 25°C)

- Burn-in Test 1: 15.2 hours
- Final Test 4: 12 hours

Automotive Test Added: Scan/Bake/Tray-Packing

Ship to Customer
Summary

- Automotive Advanced Packaging market growing strongly
- Automotive demands are challenging
- Focus on long-term suppliers with a proven automotive track record
Thank You