Minimum Requirements for a Successful Automotive Qualification With Focus on Packaging

Jan 9, 2019

Klaus Pietrczak, Director
JCET Group
### JCET Group by the Numbers

<table>
<thead>
<tr>
<th>OSAT Rank</th>
<th>Revenue (US$B)</th>
<th>Manufacturing</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1 CHINA</td>
<td>3.6 2017</td>
<td>CHINA</td>
</tr>
<tr>
<td>#3 GLOBAL</td>
<td>1.0 3Q18</td>
<td>Jiangyin Super Campus</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>IP Rank</th>
<th>Employees (K)</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1 US Patents</td>
<td>&gt;23 Globally</td>
</tr>
<tr>
<td>#1 China Patents</td>
<td>&gt;15 China</td>
</tr>
</tbody>
</table>

- **CHINA**
  - Jiangyin Super Campus
  - JCET D3, JSCC, JCAP B2

- **SOUTH KOREA**
  - SCK(+)
  - Incheon Advanced SiP/FC/WB

- **SINGAPORE**
  - SCS
  - Yishun Advanced WLP/WB
Automotive Market by Segment

- Global car production CAGR 2% per year
- Electronic Content is about to double by 2025

<table>
<thead>
<tr>
<th>Automotive Segment</th>
<th>2017</th>
<th>2022</th>
<th>CAGR</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADAS</td>
<td>$3.6B</td>
<td>$9.2B</td>
<td>19.0%</td>
</tr>
<tr>
<td>Body &amp; Convenience</td>
<td>6.9</td>
<td>9.1</td>
<td>5.4%</td>
</tr>
<tr>
<td>Chassis &amp; Safety</td>
<td>6.1</td>
<td>6.9</td>
<td>2.5%</td>
</tr>
<tr>
<td>Infotainment</td>
<td>6.6</td>
<td>8.7</td>
<td>5.1%</td>
</tr>
<tr>
<td>Powertrain</td>
<td>8.9</td>
<td>12.5</td>
<td>6.4%</td>
</tr>
<tr>
<td>Others</td>
<td>3.6</td>
<td>4.6</td>
<td>4.8%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$35.8B</strong></td>
<td><strong>$50.9B</strong></td>
<td><strong>6.9%</strong></td>
</tr>
</tbody>
</table>

Source: IHS
Device Categories:

- The segments are dominated by different semiconductor families.
- All show significant growth rates.
- WB packaging still dominate.
- New packaging technologies are entering the Automotive market:
  - Reaching mature status: fcBGA, fcCSP, MEMS
  - Entering now: SiP (MCM), WLP

### Automotive Semiconductor Market

<table>
<thead>
<tr>
<th>Semiconductor Families</th>
<th>2017</th>
<th>2022</th>
<th>CAGR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analog IC</td>
<td>$11.6B</td>
<td>$15.4B</td>
<td>5.8%</td>
</tr>
<tr>
<td>Logic IC</td>
<td>2.1</td>
<td>3.1</td>
<td>8.1%</td>
</tr>
<tr>
<td>Memory IC</td>
<td>2.5</td>
<td>4.0</td>
<td>9.9%</td>
</tr>
<tr>
<td>DSP &amp; MCU</td>
<td>7.1</td>
<td>12.2</td>
<td>11.4%</td>
</tr>
<tr>
<td>Optical</td>
<td>2.9</td>
<td>4.8</td>
<td>10.6%</td>
</tr>
<tr>
<td>Sensor &amp; Radars</td>
<td>5.1</td>
<td>7.1</td>
<td>6.8%</td>
</tr>
<tr>
<td>Discrete</td>
<td>4.4</td>
<td>6.2</td>
<td>7.1%</td>
</tr>
<tr>
<td><strong>TOTALS</strong></td>
<td><strong>$35.7B</strong></td>
<td><strong>$52.8B</strong></td>
<td><strong>8.1%</strong></td>
</tr>
</tbody>
</table>

Source: IHS
Automotive Design-in Time Line

1. Car Manufacturer defines system
2. Tier 1 design and component specification
3. Component supplier device design
4. Package design and qualification
5. Component qualification
6. System qualification
7. Summer/Winter testing
8. HVM start
1. Automotive Semiconductor Market
2. Automotive Standard Qualification Requirements
3. Other Requirements
4. Conclusions
Automotive Requirements

• A car has to be robust and reliable for > 15 years

Device level
• Today about 1ppm

ECU
• With 100 components per => 100ppm

Car
• 50 ECU per car => 5000ppm = 0.5%

Level 4/5
• 3x as many component
• 3x as many systems
• 45.000ppm = 4.5%

We must drive to <0.1ppm
Automotive Standards

OSAT Subcon
Device Supplier
System Supplier
Car Manufacturer

System Level ISO 26262-11 Class II and III

Quality Systems IATF 16949

APQP – advanced product quality planning and control plan
FMEA – failure mode and effects analysis
MSA – measurement system analysis
SPC – statistical process control

AEC Q100, active IC; AEC Q101, discrete; AEC Q006, Cupper; etc.

All above needed to support PPAP
ISO 26262

- Titled "Road vehicles – Functional safety"
  It is an international standard for functional safety of electrical and/or electronic systems in production automobiles defined by the International Organization for Standardization (ISO) in 2011
- ISO 26262 is intended to be applied to safety-related development for software, hardware and systems installed in series production passenger cars with a maximum gross weight of 3500 kg
- The ISO 26262 primarily focuses on the risks from the development of electrical and/or electronic systems, hardware and software.

Newly added chapter 11 covers functional safety on component level
It covers MCM (SiP) plus all μC and DSPs
Announced release date year end 2018
IATF 16949

- **International Automotive Task Force**
  - Purpose of this spec is the system and process improvement. It is used for factory and process qualification.
  - Main chapters cover
    - Kap. 1–3: Preamble and Generic Information
    - Kap. 4: Quality Management System (generic requirements, documents and documentation)
    - Kap. 5: Management responsibilities
    - Kap. 6: Resource Management
    - Kap. 7: Product Management
    - Kap. 8: Measurements, Analysis and Improvement

- In 1999 US (IAG), F(FIEV), UK (SMMT), GER (VDA) and I (AVSQ) combined local requirements into one TS 16949
- Several iterations have been done ever since. The latest version was released mid 2016 and is required as of Sep 2018
• **Automotive Industry Action Group**
• Covers all kind of production related requirements such as
  - **APQP** Advanced product Quality Planning
  - **DFMEA** Design Failure Mode and Effect Analysis
  - **PFMEA** Production Failure Mode and Effect Analysis
  - **SPC** Statistical Process Control
  - **MSA** Measurement System Analysis
  - **PPAP** Production Part Approval Process
    - This is the key document all involved parties have to contribute
    - Ultimately the Tier1 collects all data for proof of automotive qualification
    - IATF 16949, AIAG and AEC are subsequent contributing documents
    - Could be hundreds of pages
<table>
<thead>
<tr>
<th>Requirement</th>
<th>Level 3</th>
<th>Requirement</th>
<th>Level 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Design Record</td>
<td>S (R*)</td>
<td>10. Material, Performance Test results</td>
<td>S</td>
</tr>
<tr>
<td>6. PFMEA</td>
<td>S</td>
<td>15. Master Sample</td>
<td>R</td>
</tr>
<tr>
<td>8 Measurement Sys. Analysis</td>
<td>S</td>
<td>17. Records of Compliance</td>
<td>S</td>
</tr>
<tr>
<td>9. Dimensional Results</td>
<td>S</td>
<td>18. Part Submission Warrant</td>
<td>S</td>
</tr>
</tbody>
</table>

- S=Submit
- R=Retain
AEC covers all device qualification requirements.

There are multiple specs depending on the component technology.

Typically you need three production lots and approximately 1k pieces per lot for qualification.

This is a one time action. Proof of data has to be submitted for PPAP.

Note: some Tier1s asked for periodically repeat.

Note: OSATs cover Group A and C only

There are some requirements covering production control too (Group A).
<table>
<thead>
<tr>
<th>AEC</th>
<th>Document</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q100</td>
<td></td>
<td>Valid for single packaged ICs</td>
</tr>
<tr>
<td>Q101</td>
<td></td>
<td>Valid for discrete products</td>
</tr>
<tr>
<td>Q103</td>
<td>*</td>
<td>MEMS, currently available as draft only</td>
</tr>
<tr>
<td>Q104</td>
<td></td>
<td>MCM (=SiP), multi chip technology plus other components</td>
</tr>
<tr>
<td>Q004</td>
<td>*</td>
<td>Zero defect, currently available as draft only</td>
</tr>
<tr>
<td>Q005</td>
<td></td>
<td>Pb free</td>
</tr>
<tr>
<td>Q006</td>
<td></td>
<td>Cu wire</td>
</tr>
</tbody>
</table>

* Please feel free contact me for more details
# Automotive Part Grade Level Mapping

<table>
<thead>
<tr>
<th>Grade</th>
<th>Field Temperature Range</th>
<th>Typically required for</th>
<th>Segment Guide Line</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>-40C to +150C</td>
<td>Under the hood</td>
<td>Powertrain if close/at engine</td>
</tr>
<tr>
<td>1</td>
<td>-40C to +125C</td>
<td>Safety and System critical</td>
<td>Can be any Application if defined as critical</td>
</tr>
<tr>
<td>2</td>
<td>-40C to +105C</td>
<td>Safety, not critical e.g. ABS, you still can stop the car without</td>
<td>ADAS, Chassis &amp; Safety, Powertrain</td>
</tr>
<tr>
<td>3</td>
<td>-40C to +85C</td>
<td>Cabin electronics</td>
<td>ADAS, Infotainment, Body electronics</td>
</tr>
</tbody>
</table>

**Trend to use higher grade level than required for reliability margin**
1. Automotive Semiconductor Market
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4. Conclusions
Failure Analysis Capabilities

Steps in Failure Analysis

Assure Fail Validity
- In-lab logic/ Memory testing
  - Bench Tester
- ATE Testing
  - ATE Tester
- Parametric characteristic
  - Curve Tracer

Localize / Characterize Faults
- Intelligent fault localization - TDR
- Node measurement
  - Probe station
- Thermal detection/mapping - LCI
- Light sensing/mapping - PEM
- Microsurgery – *FIB/Laser cut

Defect Tracing / Sample Prep
- Delaying, package entry - decap
- Delid/demount X-sectioning
- Sample prep for analysis tools
  - Ion miller/polisher
- Assembly integrity verification
  - SAM/X-ray

Physical / Chemical Characteristic
- Structural characterization – 3D profiler
- Optical imaging
  - Hi-mag Scope
- Surface imaging
  - FESEM
- Thin film delam
  - SAT
- Elemental analysis
  - EDAX

Virtual capabilities: AUGER / XPS, TOF-SIMS, FTIR, FIB / TEM
Customer Complaint Handling

Check basic information. To judge if material is JCET provide

Inform customer

Inform suspect department

Check the process problem and provide 3D

FA analysis to check if the defect is caused by JCET (Optional)

To investigate the root cause and provide 8D

Communicate with customer about the 8D

OK

Case close

Verify the actions effective

CQE within 24hr

FA within 2 work days

Owner within 4 work days

CQE within 2 work days
• Product change/cancellation notification.
• JEDC 046 is a good baseline document. However time frames in automotive are much longer.
  - Notification 6 Months
  - Approval 6 Months
  - Cancellation 2 Years
• A typical flow looks like
• Every supplier has to qualify his supplier according to IATF 16949
• Typically this means qualifying the supplier against IATF 16949
• Bulk material is excluded, though some sort of qualification and control has to be in place
• OSATs do not need to qualify their supplier against IATF but need to have a qualification and monitoring in place
Data Retention and Customer Specific Requirements

• Automotive requires 15 years (data and documents)
  - Typically 5 years on-line
  - Thereafter T&R

• Customer Specific Requirements
  - Supporting the standards is not sufficient
  - All customers do have additional requirements
  - You need to have a system in place to handle such requests
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Automotive Manufacturing Footprint

1. Jianying Super Campus
   - 2,914K ft² mfg
   - JCET D3, JSCC, JCAP
   - Flip chip, leaded, laminate, bumping, WLCSP, MIS, Test

2. Low Power Discrete
   - Chuzhou, Anhui Province
   - 753K ft² mfg
   - Leaded, discrete package and test

3. Power Packaging
   - Suqian, Jiangsu Province
   - 538K ft² mfg
   - Power package and test

4. SCK
   - Incheon (IFEZ)
   - 2,445K ft²
   - Adv laminate (flip chip and stacked wirebond); SiP, pre-stack, SLT & final test

5. SCS
   - Yishun
   - 808K ft²
   - 8"/12" WLCSP, eWLB, QFN, laminate; probe & final test

Automotive Capability

<table>
<thead>
<tr>
<th>Product</th>
<th>JSCC</th>
<th>SCK</th>
<th>SCS</th>
<th>JCET</th>
<th>JCAP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flip Chip</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Wirebond</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>WLP</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>SIP</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>TEST</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>
Conclusions

- These automotive standards are a must comply
  - ISO 26262-11
  - IATF 16949
  - AIAG
  - AEC
- On top of this, there are customer specific requirements
- Documentation and data retention are important
- Customer want to buy a part and never hear from it again
  - For 15 years
  - Rain or shine

JCET Group is ready to support your Automotive needs!
For further support, contact:

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