Smart Manufacturing from the OSAT Perspective
Nozad Karim  l  VP, SiP & System Integration
## Agenda

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Amkor At-a-Glance

- A trusted OSAT partner since 1968
- > 8 M sq. ft. of manufacturing space in six countries
- Acquired J-Devices in December 2015
- Combined sales of $3.7 billion in 2015 (with J-Devices)
The Amkor Value Proposition

- **Economies of Scale**
- **Broad Geographic Footprint**
- **World Class Service**
- **Technology Leadership**
End Markets: 2015 (with J-Devices)

45%

COMMUNICATIONS
Smartphone
Tablet
Handheld device

24%

AUTOMOTIVE
Infotainment
Safety
Performance

6%

CONSUMER
Television
Set-top box
Personal electronics

10%

COMPUTING
PC/Laptop
Hard disk drive
Peripherals

15%

NETWORKING
Server
Router
Switch

Note: Includes J-Devices information for the full 12 month period
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Advanced System-in-Package (SiP)

> $725 million in sales in 2015, up 16% year-on-year
Advanced SiP Market Segments

- Wireless (front end, transceiver, …)
- Power management
- Automotive
- IoT (connectivity, MEMS, sensors, …)
- Mix-mode technology (audio, display driver, …)
Advanced SiP Module Portfolio

- RF PA, FEM
  - Single band to multi-bands PA/PAD
  - Ranging 2.0 x 2.0 mm ~ 10 x 10 mm body size in HVM
  - With core, core-less substrate designs with Cu OSP
  - Silicon, SiGe, GaAs die with CuP, wire bonding, LF solder bump
  - MUF (Mold Under Filling) with multiple filters, FCs, discrete component
    - CuP: 65 µm with 150 µm pitch in HVM and 90 µm pitch in engineering build
Advanced SiP Module Portfolio

- **MCM SCSP**
  - Stack & side by side + crystal + passives
  - Ranging 14 x 8 mm ~ 70 x 70 mm body size
  - ENEPIG substrate, DAF & FOW with Au wire

- **fcCSP**
  - WLCSP + FC + passives
  - Cu OSP substrate
  - MUF
Advanced SiP Module Business

- Growth with RF PA/PAD
  - Large installed FOL & BOL
  - Addition SMT capacity
  - Dedicated SMT module for engineering builds
  - Turnkey including bump, DPS, assembly, final test
- Current volume run rate
## Advanced SiP Assembly Capability

<table>
<thead>
<tr>
<th>Items</th>
<th>HVM</th>
<th>Advanced</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strip size</td>
<td>74 x 240 mm</td>
<td>95 x 240.5 mm</td>
</tr>
<tr>
<td>EMC</td>
<td>32µ m filler</td>
<td>20µ m filler</td>
</tr>
<tr>
<td>Solder paste</td>
<td>SAC305 type 4/5/6</td>
<td>SAC305 type 6.5</td>
</tr>
<tr>
<td>Die thickness (Wire bond with DAF)</td>
<td>0.040 mm</td>
<td>0.020 mm</td>
</tr>
<tr>
<td>Die thickness (WLCSP)</td>
<td>0.200 mm(8&quot;)/0.300(12&quot;)</td>
<td>0.150 mm(8&quot;)/0.200 mm(12&quot;)</td>
</tr>
<tr>
<td>Die thickness (CuP)</td>
<td>0.150 mm</td>
<td>0.150 mm</td>
</tr>
<tr>
<td>Substrate thickness</td>
<td>0.13 mm</td>
<td>0.1 mm</td>
</tr>
<tr>
<td>Bump pitch</td>
<td>150µ m</td>
<td>80µ m</td>
</tr>
<tr>
<td>Mold cap</td>
<td>0.4 mm</td>
<td>0.325 mm</td>
</tr>
<tr>
<td>Package thickness</td>
<td>Max 0.7 mm</td>
<td>Max 0.33 mm</td>
</tr>
<tr>
<td>EMI shielding</td>
<td>Sputtered</td>
<td>Sputtered + Compartment shielding</td>
</tr>
<tr>
<td>Passive component</td>
<td>01005 (0402m)</td>
<td>008004 (0201m)</td>
</tr>
</tbody>
</table>


SiP Process Flow

SMT Process
- IQA
- PCB Bake
- Screen Print
- 3D SPI
- FC/Component Attach
- Reflow
- De-flux
- 3D AOI

FOL Process
- Wafer Incoming
- PCB Bake
- Die Attach
- Die Attach Cure
- Plasma Cleaning
- Wire Bonding
- IVI
- 3rd QA Gate

EOL Process
- Plasma Cleaning
- Mold
- PMC
- Laser Marking
- Pkg. Saw
- AOI
- C-Shielding
- FVI/ Pack & Ship

In-line SMT module
SiP Process Flow

- **Flux printing (FC dies) & Solder paste printing (passive components)**

- **SPI (Solder Paste Inspection)**
  - Screen out defective solder printing unit

- **AOI (Automated Optical Inspection)**
  - Screen all SMT defects out with 2D & 3D
## SiP Standard BOM

<table>
<thead>
<tr>
<th>Process</th>
<th>Material</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SMT</td>
<td>Substrate</td>
<td>Cu OSP pad finish</td>
</tr>
<tr>
<td></td>
<td>Flux</td>
<td>WF6317</td>
</tr>
<tr>
<td></td>
<td>Solder paste</td>
<td>SAC305</td>
</tr>
<tr>
<td></td>
<td>Flux stencil</td>
<td>1 mil thickness</td>
</tr>
<tr>
<td></td>
<td>Solder paste stencil</td>
<td>2 mils thickness</td>
</tr>
<tr>
<td>Die Attach</td>
<td>Epoxy</td>
<td>High thermal epoxy</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Non-conductive epoxy</td>
</tr>
<tr>
<td>Wire Bonding</td>
<td>Au wire</td>
<td>2N HTS</td>
</tr>
<tr>
<td></td>
<td>Cu wire</td>
<td>Pb coated Cu wire</td>
</tr>
<tr>
<td></td>
<td>Ag wire</td>
<td>95% Ag</td>
</tr>
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# SMT Process Roadmap

<table>
<thead>
<tr>
<th>Items</th>
<th>HVM</th>
<th>Available</th>
<th>2016</th>
<th>2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>POSSUM™ FC die</td>
<td></td>
<td>Available</td>
<td>Qual</td>
<td></td>
</tr>
<tr>
<td>Passive Component</td>
<td>010005 (0.4 x 0.2 mm)</td>
<td>008004 (0.2 x 0.1 mm)</td>
<td>008004 (0.2 x 0.1 mm)/Qual</td>
<td></td>
</tr>
<tr>
<td>Embedded Passive</td>
<td>Available</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fine Pitch CuP by Chip Shooter</td>
<td>60 µm Dia. 150 µm Pitch</td>
<td>40 µm Dia. 90 µm Pitch</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SPI Application</td>
<td>Major Components</td>
<td>All including passive pad</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3D AOI Algorithm</td>
<td>Passive component</td>
<td></td>
<td>Develop for FC die (2Q)</td>
<td></td>
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Advanced SMT Module

- Full in-line hands-free module system
- OLP (Off Line Program) setup center
- Implementation of PCB map by 2D bar-code
- Smart component management system
- Component traceability (recipe control by RFID)
- PCB mapping of component batch
Advanced SMT Module

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Advanced SMT Module
Full in-line hands-free module system

- No manual handling from screen printing to de-flux
  - Reduces defects such as misalignment by manual handling
  - Possible to control the staging time of SMT process
- Reduce the bottle neck stage by series connection of chip shooter
  - Max. 4x series connection with dual lane for specific device
  - Flexible module configuration per device in component quantity on strip
Advanced SMT Module
Off line program setup center

- Setup
  - Application to mass production for device set up
  - Connection of all chip shooter by LAN cable
  - In advance feeder set up by barcode scanning
  - Reduces set up time of SMT module
Advanced SMT Module
Implementation of PCB map by 2D bar-code

- SMT process
  - Download eMap file to SPI from external FTP
  - Edit & upload PCB map to internal sever after AOI inspection
- Other process
  - Map creation by scanning the strip post WB process
  - Selective laser marking
  - Screen by 6S Auto FVI by bowl feeder

2D bar-code

FTP Server

ATK SECS GEM Server

Suppliers

IOA

S/P

SPI

Chipmount

Reflow

AOI

PCB map creator

SMT Module

D/B

Mold

Laser M/K

FVI
Advanced SMT Module
Smart component management system

- Connection with production server by RFID card
  - Material validation by system
    - Removes manual confirmation
  - Automatic selection of BOM per each lot
    - Control the 500 types of components in production line
    - Saves time not having to search
  - Records the history of withdrawal from system
    - Component traceability
- System access level separation
  - Engineer & operator level
Advanced SMT Module
Component traceability/ Recipe control by RFID

- Paperless in production line
- Alarms for the shelf life time of solder paste & flux
- Material validation with process flow
- Pop up “special requests” on monitor
- Auto log the lot in & out time
- Blocks the process bypass

Auto Login SMT Process

- Lot & device information
- SMT module #
- Operation date & time
- Stencil type
- Solder paste batch/life time
- Flux batch/life time
- PCB batch
- Component batch
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Dedicated NPI Module

- **NPI Module Configuration**
  - In-line module system with high accuracy chip shooter
  - FC support with T&R and wafer format

- **AOI (3D) Module Configuration**
  - In-line module system after SMT process
  - Possible both passive components and FC die
SMT Design Rule Roadmap

- HVM: POR SiP rules
- AVM: To meet the 2016-2017 requirement of major SiP customer device
- AVM2: More advanced design rule in comparison with AVM
- AVM3: Beyond the AVM-2 rule (assembly technology limits)
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EMI Shield

- Background
  - Conductive material makes EMI shield over package surface
  - Customer’s demand for EMI shield has been increasing to meet end customer requirement mainly for mobile business such as PA module and memory device
  - Amkor has established large scale manufacturing for EMI shielding
Conclusion

- Amkor leads the industry in advanced SiP manufacturing processes and technologies
- We are aggressively driving industry roadmaps for SiP with a broad portfolio
- Our fully automated, configurable SMT lines require no human interaction
- Our dedicated NPI module is identical to our production lines to service customer with NPI
- We have EMI shielding for miniaturization and have put a new infrastructure in place for mass production
Thank You