Automotive and AI: System Integration & Innovation in IC Packaging

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Opportunity and Challenge for automotive IC

- Global auto electronics revenue reached $134B in 2018 and is expected to grow at 6% CAGR in the next few years. Powertrain and ADAS are the 2 fastest growing applications, driven by electrification, EV, and autonomous driving mega trend.

- Both ATV OEM and Tier-1 are facing increasing margin pressure due to automotive market slow down, high tech R&D and capex requirement for new technologies like ADAS and EV.

Source: I’HS Gartner, *ASE Estimation 2017
Autonomous Driving Drives Architecture Shift

- Autonomous vehicle car semi TAM will reach >$5Bn by 2022
- Processor content from $100 (ADAS) to $1000 in autonomous vehicles

Source: Mckinsey
EV/HEV Drive Power Semiconductor

- Accelerating pure EV growth due to regulation
- Innovative packaging/module solution
- Zero Defect manufacturing

**Semi Content Per Vehicle**

- **ICE**
  - Drivertrain power semi: 17
  - Drivertrain non-power semi: 300
  - Other features: 17

- **HEV/PHEV**
  - Drivertrain power semi: 300
  - Drivertrain non-power semi: 17
  - Other features: 300

Source: Infineon, Strategic Analytics
Driven by the forces of Electrification, Autonomy, connectivity, and Comfort, the automotive industry is experiencing significant growth. With a Compound Annual Growth Rate (CAGR) of 7% for automotive sales, and around 30% growth for Original Equipment Manufacturers (OEMs) and Tier One suppliers (OSATs) used in automotive packaging, power applications need more power in the same footprint, making the development of higher power density packaging crucial. This development is critical for maintaining efficient thermal management. Many applications require electronic devices to operate in harsher environments, such as high temperature and high humidity, where reliability becomes a key factor.

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**Package Need in Automotive**

- **Driving Force:** Electrification, Autonomy, connectivity, Comfort.
- 7% CAGR for automotive sales. Around 30% growth for OSATs used in automotive packaging.
- Power applications need more power in the same footprint, thus development of a higher power density is crucial, and so thermal management becomes more important.
- For many applications, electronic devices are outside of the cabin in a harsher working environment e.g. high temperature and high humidity, and so reliability becomes a critical factor.

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*Source: Yole, 2019*
ASE Group Product coverage in Automotive Electronics

**Safety**
- Airbag Control Module
- Airbag Crash Sensors
- Event Data Recorder

**Instrumentation**
- Instrument Cluster
- Head-Up Display

**ADAS**
- ADAS Control Module
- Camera Modules
- Sensor Modules
- V2X Communications

**Chassis**
- Antilock Braking (ABS)
- Stability Control
- Tire Pressure Monitoring
- Steer/Brake-by-Wire

**Body**
- Climate Sensor Control
- Remote Keyless Entry
- Lighting Control
- Position / Angle Sensors
- Electronic Control Units

**Infotainment**
- Fixed Navigation Systems
- Rear Seat Entertainment
- NFC BT Pairing
- Wireless Charging

**Powertrain**
- Engine Control Module
- Transmission Control Module

**Aftermarket**
- Portable Navigation Devices
- Audio Head Units
- Video Recorders

**Grade**
- Grade 0
- Grade 1
- Grade 2
- Grade 1
- Grade 1
- Wettable QFN Grade 1
- BGA Grade 1
- Open Cavity QFN 1
- FCCSP Grade 1

Two-tier structure is projected in Automotive Electronics:
- Body, 31%
- Chassis / Safety, 31.40%
- Infotainment, 16%
- Aftermarket, 21.30%
- Others, 0.10%

Grade 2 devices are mainly used in Automotive Electronics.
Modularization/SiP Trend

Infotainment
- Audio Head Units
- Fixed Nav. System
- Infotainment Head Units
- Rear Seat Entertainment

Body
- Climate Control
- Remote Keyless Entry
- Lighting
- Electronic Control Units

ADAS
- ADAS Control Module
- Camera Modules
- Sensor Modules
- V2X Communication
Automotive System-in-Package

ASE

ATV

SiP

Power

Sensors

RF connectivity

Computing - AI
Emerging Technologies – Maturity

Years to Mainstream Adoption

- **Less than 2 years**
  - Deep Learning
  - Virtual Assistant
  - 5G
  - Neural Network
  - ASICs

- **2 to 5 years**
  - Blockchain
  - Edge AI
  - Conversational AI
  - Platform
  - Neuromorphic Hardware
  - Smart Workspace

- **5 to 10 years**
  - Mixed Reality
  - Augmented Reality
  - Blockchain for Data Security
  - Connected Home
  - IoT Platform
  - Smart Fabrics

- **More than 10 years**
  - Flying Autonomous Vehicles
  - Volumetric Displays

Source: Priority Matrix for Emerging Technologies 2018, Gartner
IoT and Cloud create the need for edge computing where data collecting & processing occurs in part at the network edge, rather than completely in the cloud.

Edge devices must manage complex operations, including sensing, compute, power management, and localized AI.

Edge compute can address latency, battery life, bandwidth costs, security, privacy, to allow timely decision & 1st level data analysis.

Heterogeneous integration provides a platform for multiple die from multiple sources to be packaged together, offering huge performance, power and footprint advantages.
Power delivery innovation is needed to address increasing SOC / AI accelerators & power consumption: optical solutions provide high bandwidth bridge within AI solutions.

Processor memory integration saddled by memory bandwidth bottleneck: possible solution is SOC HBM packages such as CoWoS, EMIB, 2.5D.

AI accelerators such as TPUs and neural ASICs enable the industry to have a comprehensive AI ecosystem.

Skyrocketing data volume demands dramatic increase in processing power and performance, achievable through new innovation in technology integration.
HPC Package Integration Solutions

**FCBGA MCM**
- Interconnection through substrate
- D2D Interconnection: ~1K
- L/S 10/10
- Max qualified pkg size: 75x70 FCBGA
- Min die to die gap: 60 um

**FOCoS**
- Interconnection through fanout RDL
- D2D Interconnection: ~10K
- L/S 2/2
- Max fanout die size: 26x33
- ASIC+HMB: Engineering
- Chip last solution for > 3 die fanout

**2.5D**
- Interconnection through silicon
- D2D Interconnection: ~100K
- L/S 0.4/0.4
- HBM; Hetero/ Homogeneous die partition
- Interposer: 1400mm2
- Available on cavity lid, stiffener and
Group Synergies Leading to Disruptive Innovation

Smartest package solution for IoT, mobile, ATV etc...!
Device Integration: Bridging OSAT & EMS

**SiP Module**

- **Device Integration:** Bridging OSAT & EMS
- **SoC**
- **3D IC APU, Memory**
- **2.5D IC FPGA, GPU, NPU**
- **WiFi/BLE**
- **RF / FEM**
- **Optical**
- **PMU**
- **Camera**
- **Biometric**
- **SSD**
- **Touch Sensor**
- **VR Headset**
- **Fitness**
- **IoT**
- **SmartWatch**
Enabling Technologies for SiP/SiM

- **Interconnection**
  - Flip chip bond
  - Wire bond

- **Antenna**
  - Package integration (2.4G/5G/60GHz)
  - Exposed die
  - Double side

- **Molding**
  - MUF
  - WLCSP / FC Die Bond
  - Package Bond

- **Shielding**
  - Conformal
  - Compartmental

- **Passives / IPD**
  - 0201 / 01005
  - 008004
  - Silicon IPD
  - Glass IPD

- **Wafer Bumping / WLP**
  - Leadfree / Cu Pillar
  - WLCSP
  - FOWLP

- **Embedded Technology**
  - Passive component
  - Active device (L/F)
  - Active device (Sub.)
  - SESUB

- **Die / Pkg Stacking**
  - Die thinning
  - Die stacking
  - Package stacking

- **Mechanical Assy**
  - Laser welding
  - Flex bending

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ASE SiP Package Solution Focus

Wireless SiP

Wireless+MCU

Sensor SiP

IoT & Wearable Platform

Sensor SiP for Personal
- RF+MCU+Sensors (Motion, Physiological)
- Application:
  Personal Body Motion, Gesture & Physiological Sign Sensing

Sensor SiP for Home
- RF+MCU+Sensors (Motion, Environment)
- Friendly Development Kit (Arduino)
- Application:

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Food for Thought: Supply Chain Consolidation

OSAT → IC Suppliers → Tier-1 → Car OEM

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