SiP Modules
Application Driven Integration

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ASE Group at a Glance

- Established 1984, production commenced at flagship factory in Kaohsiung, Taiwan.
- IC Assembly, Test & Materials (ATM) achieved global market leadership in 2004, surpassing all players in OSAT industry.
- Completed acquisition of Universal Scientific Industrial Co. (USI) to expand DMS module & system manufacturing capability.
- Operations now at 18 facilities worldwide, serving multiple markets, applications, & geographies.
- >60K employees: Global team comprises operations, engineering, R&D, sales & marketing.
- ASE Group overall revenue of $8.95B in 2015, 5% over 2014
ASE’s Role in the Manufacturing Value Chain

Unique Turnkey Solution Bridging OSAT & EMS/ODM
Group Synergy

ASE Group
Financial strength & investment
Manufacturing capability & scale
End to end engineering services
Rapid time to market
Turnkey management
Cost effective

ASE Assembly & Test
- Package design
- Microelectronic assembly technologies
- Process automation & control
- Semiconductor quality
- High yield processes

ASE Material
- Materials engineering
- Technology development
- Substrate manufacturing

USI
- System design
- Supply Chain Management
- High density SMT
- Logistics management
- System Level Test

ISE Labs
- Test program development
- Engineering test services
- Test interface hardware
- Qualification & reliability test
- Failure analysis

Full turnkey solution – from design to delivery
SiP Module Overview
“The future of integrated electronics is the future of electronics itself. The advantages of integration will bring about a proliferation of electronics, pushing this science into many new areas. ...........”

Gordon Moore, April 19, 1965

Today’s reality leverages complementary and parallel integration paths

- SoC integration continues for advanced products requiring Moore’s Law performance & density
- SiP heterogeneous device integration for rapid NPI and cost sensitive applications
Industry Dynamics Driving SiP Modules

- Moore’s Law slowing & divergence
  - Increasing SoC development leadtime and cost (4X from 28nm to 14/16mn)
  - Need for alternative to SoC integration - higher cost/transistor for advanced process nodes

- Value chain consolidation – supply chain re-verticalization
  - Content providers developing hardware systems to differentiate ecosystems
  - Need for rapid NPI - BOM simplification, lower cost and reduced time to market

- Global connectivity acceleration
  - Mobile, wearable and IoT systems driving miniaturization
  - Need for re-configurability - rapidly changing standards and application requirements

- SiP modules provide alternative solutions for functional integration, miniaturization, optimization and cost reduction
SiP / SiM are package or module based solutions that contain an application focused functional electronic system or sub-system that is integrated and miniaturized through IC assembly technologies.
System Miniaturization

- SiP is an IC package that includes active die and SMT components
- SiM is stand alone or connector based module utilizing IC and SMT miniaturization technologies

System Miniaturization and Modularization Examples

- Wearable
- IoT devices
- NUC (Next Unit of Computing)
- Compute stick

System leveraged “sub systems”

- Connectivity modules – WiFi, BT/BLE, Zigbee
- Storage modules - SSD
- Sensor modules – Biometric, IMU, Pressure, Light/Proximity
SiP Module Benefits

- Highly heterogeneous integration - including different wafer technologies
- Miniaturized by SiP core technologies
- Performance optimized - signal integrity and power
- Decreased development time – rapid NPI
- Lower cost alternative to SoC
- Simplified system PCB & BOM – improved reliability
- Flexible, re-usable & re-configurable
- One step closer to stand-alone system
In many cases, systems are made of a weighted mix of SoC, SiP and SoB
Example – Smart Phone Evolution

System miniaturization enabled by SiP
Enabling Technologies & Examples
Heterogeneous Integration
FanOut Bridging the Interconnect Density Gap

SiP
- Embedded
- PoP
- FC CSP
- LD FOSiP
- HD FOSiP PoP
- HD FOCoS
- HD FOWLP
- LD FOWLP

Multi-Die Pkg

L/S (um)

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## Fan Out Based Solutions

<table>
<thead>
<tr>
<th>Technology</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td><strong>eWLB</strong></td>
<td>BB, RF, Codec, PMIC, Car Radar, KGD</td>
</tr>
<tr>
<td><strong>FOCLP</strong></td>
<td>BB, RF, Codec, PMIC, Chip last, Coreless substrate, Cu pillar flip on ETS (40um), Lower cost FO, Small form factor</td>
</tr>
<tr>
<td><strong>FOCoS</strong></td>
<td>Networking, Server, Chip first, FCBGA assembly, Die partition, High I/O connect (&gt;1000), Good electrical, Alternative to 2.5D</td>
</tr>
<tr>
<td><strong>FO PoP</strong></td>
<td>AP &amp; Memory Integration, Chip first, Wafer FO, Thin package height, Package on package, High bandwidth performance, Passive integrated</td>
</tr>
<tr>
<td><strong>FO SiP</strong></td>
<td>AP &amp; Memory Integration, RF Module, Chip last, Wafer FO, Known good RDL, Small &amp; low profile module, Fully functional system</td>
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</tbody>
</table>

- **eWLB**
  - Max. Pkg size ~10x10
  - RDL L/S > 8/8um
  - 2L RDL
  - Chip first
  - Wafer FO
  - High I/O WLP
  - Substrate-less
  - Small form factor
  - KGD

- **FOCLP**
  - Max. Pkg size ~12x12
  - RDL L/S > 12/12um
  - 1L RDL

- **FOCoS**
  - Max. Pkg size ~45x45
  - RDL L/S > 2/2um
  - 3L RDL

- **FO PoP**
  - Max. Pkg size ~15x15
  - RDL L/S > 5/5um
  - 3L RDL

- **FO SiP**
  - Max. Pkg size ~15x15
  - RDL L/S > 5/5um
  - 3L RDL
SiP Enabling Technologies

1. Interconnection
   - Wire Bond
   - Flip Chip
   - TSV

2. Encapsulation
   - Exposed Die
   - Irregular Shape
   - Selective Area
   - Double Sided

3. Wafer Level Process
   - IPD
   - WLP / Fan-Out
   - FOCoS

4. Embedded Technology
   - TDK SESUB
   - aEASI

5. Die / Pkg Stacking
   - Multi-die stack
   - 2.5D, 3DIC
   - PoP, PiP

6. System Assembly
   - HD-SMT
   - Rigid / Flex
   - Mechanical Assy

7. MEMS / Sensor
   - Motion
   - Environmental
   - Image / Optical

8. Shielding / Antenna
   - Conformal Shielding
   - Compartment Shielding
   - Antenna on/in package
Wireless Connectivity - WiFi

- Application: WiFi 802.11 a/b/g/n 2x2 + BT4.0 for mobile and wearable

Now: Single Sided Module
Module Size: 10.0x6.6x1.1 mm

Solution: Double Sided Molding Module
Module Size: 7.75 x 5.4 x 1.3 mm

- Services Provided: Module Design & Manufacturing
- Technologies Leveraged:
  - Double Side SMT
  - Double Side Molding & Exposed Molding
  - Conformal Shielding
- Benefit Realized: 30% module XY size reduction
Wireless Connectivity – BLE

- Application: Bluetooth Low Energy (BLE) for Wearable Product

Current: Single Sided Module with Chip Antenna
Module Size: 15.0 x 15.0 x 2.0 mm

Solution: AoP (Antenna on Package)
Module Size: 6.5 x 6.5 x 1.2 mm

- Services Provided: Module Design & Mfg.

- Technologies Leveraged:
  - AoP (Antenna on Package)

- Benefit: 82% module XY size reduction
Sensor – Optical HRM

- **Application**: Body motion & physiological sign sensing in mobile/wearable

Now: Discrete on PCBA
*Module Size: 15.0 x 15.0 x 1.7 mm*

Now: Integrated Sensor
*Module Size: 6.6 x 2.4 x 0.78 mm*

- **Services Provided**: Module design and manufacturing, system-level testing & firmware co-qualification

- **Technologies Leveraged**:
  - Embedded Die Substrate
  - Clear compound molding with micro-structure enhancement

- **Benefit**:
  - 84% module XY size reduction
  - Better optical signal interference isolation
  - Less parasitic resistance & capacitance
Application focused SiP – advanced technology & full turnkey supply solutions
Innovative IC, System-in-Package, and MEMS packaging portfolio for today’s miniaturization, mobility, and IoT needs.

Wire Bond  Flip Chip  WLP  2.5D & 3D  Fanout  SiP

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Thank You

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