Innovative 3D-SiP Package Technologies for More than Moore Era

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Outline

◆ Packaging Trend of SMART Phone/ Wearable/ Networking Devices

◆ Innovative 3D-SiP Packaging Technologies

◆ Summary
IC Device Applications in Mobile

1. 處理器晶片 (AP) (Application Processor)
2. 基頻晶片 (BB) (Baseband Processor)
3. 相機模組 (CCM) (CMOS Camera Module)
4. 音訊濾波晶片 (Audio filter)
5. 射頻晶片 (RF) (Radio Frequency)
6. 指紋辨識晶片 (FPS) (Finger Print Sensor)
7. 通訊晶片 (Connectivity) (Wifi / Bluetooth)
8. 電源管理晶片 (PMIC) (Power Management IC)
3D-SiP Market Growth Rate Overview

Source: Gartner, Morgan Stanley, Market Information

Most IC Device Applications were designed into 3D-SiP modules!!

Confidential
Innovative **3D-SiP** Package Technologies

I. SiP TECHs

II. Fan-Out WLP

III. 2.5D IC

**Product Features:**
- Small form factor with high function integration
- Higher performance (Electrical/Thermal/Mechanical)
- High C/P ratio (High value, but low cost)

HOT!!
Innovative 3D-SiP Package Solutions

SiP (System in PKG)

Fan-Out WLP

2.5D IC
**3D-SiP Benefits & Challenges**

**Application:**
WiFi/ BT/ NFC / GPS / FM Module Development

**Benefits:**
SiP can provide the *small form factor, low cost* and *multi-function integration* solutions.

**Challenges:**
- Some KEY technologies are needed to develop ASAP !!!
  1. EMI shielding
  2. Antenna on PCB
  3. Die on passive component
  4. IPD/Die embedded in PCB
**3D-SiP Miniaturization Tech Solutions**

- **MCU + WiFi COB Solution**
  - Size: 22x19mm
  - Include WiFi + MCU
  - Component Count: 50
  - Process: wafer thinning, stack Die on FC, MUF, EMI Coating

- **MCU + WiFi SiP solution**
  - Size: 10x10mm

- **MCU + BLE COB Solution**
  - Size: 18x12mm
  - Include BLE, Flash, X’tal, Antenna
  - Component Count: 28
  - Process: Stack die on Passives, Antenna in Package, Compress Molding

- **MCU + BLE SiP solution**
  - Size: 6.5x6.5mm

**80% size reduction**

**85% size reduction**

- **WiFi Sensor Hub**
- **WiFi Plug**
- **WiFi Air Conditioner**
- **WiFi Bulb**
- **BLE Locker**
- **BLE Toy**
- **iRhytm**
- **Hearing Aid**
- **Swimming Band**
- **Hand Band**
- **WiFi Air**
- **WiFi Miniaturization Tech Solutions**
Innovative PKG Technologies for 3D-SiP

1. Embedded Actives
   - Small PKG Size/Height

2. Embedded Passives
   - Lower PKG Z Ht /
   - Lower Power Consumption
   - Low EMI Noise

3. Two side PKG
   - High Yield /
   - High Integration

4. Die on CAP
   - Better Electrical Performance

5. Die on CAP (F2F)
   - Small Form Factor/ High Integration

6. Partition LMI
   - Small Form Factor/ High Integration

7. Antenna in SiP
   - Small PKG Size

Its Happen Now!!
**3D-SiP New Package TECH. Trend**

(CAGR $\rightarrow$ 39.3% / 55.8%)

**Benefit:**

1. High function Integration
2. Small form Profile Performance

**Antenna in SiP**

**2 Side SiP**

**Partition EMI**

**Now!!**

**Next Generation!!**
Innovative 3D-SiP Package Solutions
# FO-WLP PKG Category & Its Product Applications

<table>
<thead>
<tr>
<th>I/O Density</th>
<th>RDL L/S(um)</th>
<th>PKG Solution</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2</td>
<td>Silicon Interposer</td>
<td></td>
</tr>
<tr>
<td>High</td>
<td>2</td>
<td>FO-PoP</td>
<td>Mobile Application: 1. Smart Phone &amp; Tablet 2. High End AP/BB</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>HBW-PoP</td>
<td></td>
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<tr>
<td>Low</td>
<td>&gt;10</td>
<td>FO-SD</td>
<td>Mobile Application: 1. Low Pin Count 2. PMIC/RF/PA</td>
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<td></td>
<td></td>
<td>FC-ETS</td>
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<tr>
<td>Middle variability</td>
<td></td>
<td>FO-SIP</td>
<td>IoT/Wearable Application: 1. Connectivity module 2. PMIC Module</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SIP Module</td>
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Why Fan-Out WLP Technology?

**Application:**
Keep sufficient area for PCB board I/O as the die size shrinking (28/20/16nm), application for Mobile AP/ Baseband/ PMIC and HDD/SSD Controller.

**Benefits:**
- Small form factor & thinner package (substrate-less).
- High IO/High bandwidth with fine line/multi-layer RDL routiability. (Line/Space = <10µm, >2L RDL layer)

**Challenges:**
- Wafer Warpage & Poor BLR (Board Level Reliability)
3D-SiP Package Apply for AP/BB in Smart Phone

**ePoP & BD-PoP**
- PKG THK: 1.2~1.5mm
- PKG THK: 1.2mm

**HWB-PoP & FO-PoP**
- (High Bandwidth)
- PKG THK: <1.2mm
- PKG THK: <1.1mm

**FO-PoP+FO-MCM**
- (Ultra Thin Profile)
- (Z ht <0.5mm)
- PKG THK < 1mm

**Benefit:**
1. High Electric & Thermal Performance
2. Ultra thin Profile Performance

NOW!!
Next Generation!!
Innovative 3D-SiP Package Solutions

SiP (System in PKG)

Fan-Out WLP

2.5D IC
Why 2.5DIC Technology?

The Trend of Future!

- Heterogeneous integration
- Smaller PKG size
- Higher performance

AI Market
(deep learning, supercomputer)
**OSAT Role in 2.5DIC Supply Chain**

- **Enabling technologies development for 2.5DIC MEoL and BEoL capability.**
- **Same capability capable for 3DIC.**
- **For TSV Silicon Interposer (TSI), OSAT collaborate with wafer foundries.**
**2.5DIC** Key Enabling Technology

Challenges: **Wafer Warpage** & **Poor PLR** (Package Level Reliability)
2.5D Packaging Readiness

- **Precon (L4/ reflow 245°C)**: RFL 3x, Pass
- **TCG (-40~125°C)**: 1000x, Pass
- **uHAST (Ta=130°C/RH 85%)**: 96hr, Pass

- No abnormal was observed on **C4 bump joint**, UF dispense and adhesive process
- 1 ASIC +4HBM structure passed L4 + TCG1000
**Merits of 2.5D IC to FO-MCM Platform**
- Shortening interconnection distance - high speed & bandwidth performance.
- Reducing interposer cost due to excluding TSV related process cost.
- Processing by all existing MEoL/BEOl equipments.
2.1D (by Substrate) - Low Cost Alternatives of 2.5D

- Organic Interposer: (w/ core)
  - Organic Substrate replace Si interposer as interface between die & substrate.
  - Characteristic:
    - Fine pitch: trace L/S >> 10/10 → 2/2um

- Fine L/S capacity
  - 2014 capability (L/S=5/5)
  - 2016 capability (L/S=2/2)
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Conclusion

- **New Package TECHs Focus on Three 3D-SiP**

- **System in Package** *(w/ 7 miniaturization TECH)*

- **Fan-Out Wafer Level Package** *(Substrate-less; for thin & small form factor)*

- **2.5DIC PKG** *(w/ Low Cost PKG solutions; such as 2.1D Substrate)*
Thank You For Your Attention!!!

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