Market and Technology Trends of Advanced Packaging

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Trends & Drivers: Opportunity for advanced packaging

System requirement
- More computing power
- More bandwidth
- Lower latency
- Lower power consumption
- More functionality
- System integration
- More memory
- Lower cost
- Lower form-factor

Opportunity for various devices
- CPUs, GPUs, SoCs, APUs, FPGAs
- ASICS, DSPs, MCUs
- MEMS/Sensors
- Power ICs/discretes
- Memory
- Optoelectronics

Opportunity for advanced packaging

Main applications (non-exhaustive)
- Fan-Out Packaging: RF, PMIC, Audio, Connectivity, APU, (x)PU, ASIC, FPGA
- WLCSP Fan-In Packaging: RF, PMIC, Audio, Connectivity, Driver IC, DC/DC converter
- System-in-Package (SIP): AIP/mmW, FEM, FEM PIC module, Wi-Fi/BT module
- FCBGA Packaging: (x)PU, networking ASIC, FPGA, automotive & infotainment modules
- FCCSP Packaging: APU, RF, Baseband, PMIC, memory
- 2.5D/3D Stacked Packaging: (x)PU, ASIC, FPGA, 3D NAND, HBM, CIS
Advanced Packaging Roadmap: I/O Pitch and RDL L/S

Advanced Packaging Technology Roadmap

<table>
<thead>
<tr>
<th>Year</th>
<th>2015</th>
<th>2017</th>
<th>2019</th>
<th>2021</th>
<th>2023</th>
<th>...2027</th>
</tr>
</thead>
<tbody>
<tr>
<td>W2W</td>
<td>2 μm</td>
<td>1 μm</td>
<td>&lt;0.5 μm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D2W</td>
<td></td>
<td>10 μm</td>
<td>&lt;10 μm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D2D</td>
<td></td>
<td></td>
<td>10 - 60 μm</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Bump I/O Pitch**
  - 200 to 150 μm
  - 80 to 10 μm
  - 50 to 40 μm

- **L/S**
  - >10/10 μm
  - >8/8 μm
  - >5/5 μm
  - >2/2 μm

- **Ball I/O Pitch**
  - 1200 to 350 μm
  - 300 μm

Roadmap represents minimum values at HVM production. Does not include R&D capability.
Definition of a Chiplet

‘Chiplet’ describe an emerging semiconductor design philosophy that combines two or more discrete die in a disaggregated or duplicated processor SiP design, allowing for more design flexibility, faster time to market, better yield, and thus an economic benefit over a possible monolithic alternative. The functions of the discrete chiplets should be among the IP blocks found in a typical processor SoC, including, but not limited to: CPU, GPU, NPU, I/O and memory controllers and interfaces, cache memory, and analog functions (SerDes, PLLs, DAC, ADC, PHYs, etc).
What counts as a Chiplet?

The answer is Disaggregation and Duplication

Disaggregation: the SoC monolithic die is partitioned in smaller chips with different functions, then interconnected in the same package.

Duplication: two or more SoC monolithic dies are interconnected in the same package forming a bigger SoC.
Chiplet ECOSYSTEM

Benefits
- Improved Yield
- Different Technology Node
- Cost Saving
- Reduce Design Time

Heterogeneous Integration
KGD, Si-bridge, Hybrid Bond, Clean Process

More universal design and standardization from co-design to packaging, assembly and test

New Techniques and Standards
New and specific solutions to tag along with chiplet technologies

Collaboration Initiative
Many collaboration initiatives to standardize the chiplet ecosystem

Chiplet

Players*
Chiplet products have been introduced since 2016, and there are more to come by various players.

Assembly suppliers*
TSMC (Foundry) and Intel (IDM) are the first to assemble chiplets. OSATS are lining up to develop the capability.

Challenges
- Integration of different chiplets
- Power and thermal distribution
- New test methodology
- Open business model

2016
Now
Boom Cycle
2028
## Commercialized & Announced Products

<table>
<thead>
<tr>
<th>Company</th>
<th>Strategy</th>
<th>Products*</th>
</tr>
</thead>
</table>
| **intel** | Chiplet and heterogeneous integration is focus of IDM 2.0 strategy. | Sapphire Rapids (EMIB)  
Launched Q1 2023 | Ponte Vecchio (Co-EMIB)  
Available 2023 | Meteor Lake (Foveros)  
Available 2023 | Foveros Direct  
Available 2024 |
| **AMD** | AMD has now shipped several generations of PC and server processors using its chiplet interconnect platform Infinity Fabric (IF). AMD uses organic substrate to integrate chiplets. | AMD Ryzen Series  
Ryzen 3000  
Launched 2019 | AMD Radeon Instinct™ MI200  
Series  
Launched 2022 | 3D-V Cache in AMD Ryzen and EPYC Gen3  
Launched 2022 | AMD Radeon RX7900  
Launched 2022 |
| **Apple** | Apple recently released its M1 Ultra product which is a combination of two M1 Max dies interconnected using TSMC’s LSI technology. | M1 Ultra (with TSMC InFO-LSI)  
launched 2022 |
| **Amazon** | Amazon launched their Graviton3 data center processor during their AWS in 2021. It is a chiplet product with seven dies and a total of 55 Bn transistors. | Graviton3 (with Intel’s EMIB technology)  
Launched 2022 |

*Non-exhaustive list
Advanced Packaging Market Trends
ADVANCED PACKAGING MARKET DYNAMICS – REVENUE

Advanced Packaging Market Revenue ($B)

Source: Q1 23, Advanced Packaging Market Monitor

Only for SSEA 2023. Please contact Yole Group for citing.
Advanced packaging revenues of the top 6 players in 2022

- 3D Stacked: 28%
- WLCSP: 12%
- FO: 49%
- FC bumping: 13%
- FCBGA: 30%
- FCCSP: 31%
- SiP: 25%

*Excluding traditional packaging platform, Front-end dies and test revenue

Source: Q1 23, Advanced Packaging Market Monitor
2021-2023 CapEx highlights for top Packaging players

Source: Q1 23, Advanced Packaging Market Monitor
Advanced IC Substrate
Advanced IC substrate applications by packaging platform

Where is advanced IC substrate used in advanced packaging?

**Flip-chip BGA/CSP**
- FC BGA package
- FC CSP package

**Fan-out on Substrate**
- Ultra-High-Density Fan-Out (UHD FO)
  - e.g., InFO-oS (TSMC), FOCoS (ASE)
- Board

**Embedded Die**
- Embedded die in IC substrate
- PCB

**2.5D/3D**
- Silicon interposer, silicon bridge
  - e.g., CoWoS (TSMC), EMIB, Foveros (Intel)
- PCB

Please contact Yole Group for citing
Advanced IC Substrate Market Forecast

Advanced IC Substrate: Market Revenue Forecast [$B]

Source: Status of the Advanced IC Substrate Industry 2022
Advanced IC Substrate Investment Ranking (2021-2022)

Source: Status of the Advanced IC Substrate Industry 2022
Conclusion

• Advanced Packaging has become the essential solution for heterogeneous integration.

• A key trend driving Advanced Packaging is the adoption of a chiplet approach to attain heterogeneous integration.

• IDMs and foundries are taking market shares from OSATs for advanced packaging, especially for the most high-end technologies like 2.5D and 3D, ultra-high-density fan-out and some advanced SiP.

• Advanced packaging demand is still increasing, and the market growth is mainly propelled by automotive, 5G.

• In 2023, the packaging CapEx of the top players is expected 17% lower than the previous year.

• Advanced IC substrate has high investment in 2021 and 2022, substrate shortage issue will be overcome soon.
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Based in Malaysia, Yik Yee follows the semiconductor packaging industry and its evolution. Based on her technical expertise and market knowledge, she develops technology and market reports and is engaged in creating dedicated custom projects.

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