<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>A&amp;D</td>
<td>Aerospace and Defense</td>
</tr>
<tr>
<td>ABF</td>
<td>Ajinomoto Build-up Film</td>
</tr>
<tr>
<td>ACPS</td>
<td>ACCESS Clipless Power Stage</td>
</tr>
<tr>
<td>A-EASI</td>
<td>Advanced-Embedded Active System Integration</td>
</tr>
<tr>
<td>AI</td>
<td>Artificial Intelligence</td>
</tr>
<tr>
<td>APE</td>
<td>Application Processor Engine</td>
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<tr>
<td>AR</td>
<td>Augmented Reality</td>
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<tr>
<td>ASIC</td>
<td>Application-Specific Integrated Circuit</td>
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<tr>
<td>ASP</td>
<td>Average Selling Price</td>
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<tr>
<td>BE</td>
<td>Back-End</td>
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<tr>
<td>BGA</td>
<td>Ball Grid Array</td>
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<tr>
<td>CAGR</td>
<td>Compound Annual Growth Rate</td>
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<tr>
<td>CIS</td>
<td>CMOS Image Sensor</td>
</tr>
<tr>
<td>CPU</td>
<td>Central Processing Unit</td>
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<tr>
<td>CSP</td>
<td>Chip Scaled Package</td>
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<tr>
<td>DC</td>
<td>Direct Current</td>
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<tr>
<td>DMS</td>
<td>Design Manufacturing Services</td>
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<tr>
<td>DSP</td>
<td>Digital Signal Processor</td>
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<tr>
<td>DTV</td>
<td>Digital TV</td>
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<tr>
<td>ECP</td>
<td>Embedded Component Package</td>
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<td>ED</td>
<td>Embedded Die</td>
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<tr>
<td>eHDF</td>
<td>embedded High Density Film</td>
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<tr>
<td>EMIB</td>
<td>Embedded Multi-die Interconnect Bridge</td>
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<td>EMS</td>
<td>Electronics Manufacturing Service</td>
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<tr>
<td>ETS</td>
<td>Embedded Trace Substrate</td>
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<tr>
<td>EV/HV</td>
<td>Electrical Vehicle/Hybrid Vehicle</td>
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<tr>
<td>FC</td>
<td>Flip Chip</td>
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<tr>
<td>FC-EIC</td>
<td>Flip Chip Embedded Interposer Carrier</td>
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<td>FE</td>
<td>Front-End</td>
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<td>Fi</td>
<td>Fan-In</td>
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<td>FO</td>
<td>Fan-Out</td>
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<td>FO SiP</td>
<td>Fan-Out System-in-Package</td>
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<td>FO WLP</td>
<td>Fan-Out Wafer Level Packaging</td>
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<tr>
<td>FO-SIB</td>
<td>Fan Out System in Board</td>
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<td>FPC</td>
<td>Flexible Printed Circuit</td>
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<td>FPGA</td>
<td>Field Programmable Gate Array</td>
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<td>GaN</td>
<td>Gallium Nitride</td>
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<tr>
<td>GPU</td>
<td>Graphics Processing Unit</td>
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<tr>
<td>HBM</td>
<td>High Bandwidth Memory</td>
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<tr>
<td>HD</td>
<td>High Density (Fan-Out) OR High Definition (TV)</td>
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<tr>
<td>HDI board</td>
<td>High Density Interconnect Board</td>
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<td>HIPS</td>
<td>Heterogeneous Integrated Power Stages</td>
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<td>HPC</td>
<td>High Performance Computing</td>
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<td>HVM</td>
<td>High Volume Manufacturing</td>
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<tr>
<td>I/O</td>
<td>Input/Output</td>
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<td>IC</td>
<td>Integrated Circuit(s)</td>
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<td>ICE</td>
<td>Internal Circuit Engine</td>
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<td>ICT</td>
<td>Information Communication Technology</td>
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<td>IDM(s)</td>
<td>Integrated Device Manufacturer(s)</td>
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<td>IoT</td>
<td>Internet of Things</td>
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<tr>
<td>IP</td>
<td>Intellectual Property</td>
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<tr>
<td>i-ThOP</td>
<td>integrated Thin film High density Organic Package</td>
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<tr>
<td>LS</td>
<td>Line/Space</td>
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<td>LED</td>
<td>Light Emitting Diode</td>
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<td>LGA</td>
<td>Land Grid Array</td>
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<tr>
<td>M&amp;A</td>
<td>Merger &amp; Acquisition</td>
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<td>MCEP</td>
<td>Molded Core embedded Package</td>
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<tr>
<td>MCM</td>
<td>Multi-Chip Module</td>
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<td>MEMS</td>
<td>Micro-Electro Mechanical Systems</td>
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<td>MIS</td>
<td>Molded Interconnection Substrate</td>
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<tr>
<td>mSAP</td>
<td>modified Semi-Additive Process</td>
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<tr>
<td>ODM</td>
<td>Original Design Manufacturer</td>
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<td>OEM</td>
<td>Original Equipment Manufacturer</td>
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<tr>
<td>OSAT</td>
<td>Outsourced Semiconductor Manufacturer</td>
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<tr>
<td>PCB</td>
<td>Printed Circuit Board</td>
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<td>PCBA</td>
<td>Printed Circuit Board Assembly</td>
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<td>PiP</td>
<td>Package in Package</td>
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<td>PKG</td>
<td>Package</td>
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<td>PLP</td>
<td>Panel Level Packaging</td>
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<td>PMIC</td>
<td>Power Management IC</td>
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<td>PMU</td>
<td>Power Management Unit</td>
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<td>POL</td>
<td>Power Overlay</td>
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<tr>
<td>PoP</td>
<td>Package on Package</td>
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<tr>
<td>PTH</td>
<td>Plated Through Hole</td>
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<tr>
<td>PWB</td>
<td>Printed Wiring Board</td>
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<td>QFN</td>
<td>Quad Flat No-Leads</td>
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<td>QFP</td>
<td>Quad Flat Package</td>
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<tr>
<td>RDL</td>
<td>Redistribution Layer</td>
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<td>RF</td>
<td>Radio Frequency</td>
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<td>SAP</td>
<td>Semi-Additive Process</td>
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<td>SeSUB</td>
<td>Semiconductor Embedded in SUBstrate</td>
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<td>SiC</td>
<td>Silicon Carbide</td>
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<tr>
<td>SiM</td>
<td>System in Module</td>
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<td>SiP</td>
<td>System-in-Package</td>
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<td>SLP</td>
<td>Substrate Like PCB</td>
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<td>SMD</td>
<td>Surface Mount Die</td>
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<td>SMT</td>
<td>Surface Mount Technology</td>
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<td>STB</td>
<td>Set-Top Box</td>
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<td>TO</td>
<td>Transistor Outline Package</td>
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<tr>
<td>TPV-Frame</td>
<td>Through Prepeg Via in Frame</td>
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<tr>
<td>TSV</td>
<td>Through-Silicon-Via</td>
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<tr>
<td>TXVR</td>
<td>Transceiver</td>
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<tr>
<td>VR</td>
<td>Virtual Reality</td>
</tr>
<tr>
<td>WABE</td>
<td>Wafer And Board level device Embedded</td>
</tr>
<tr>
<td>WB</td>
<td>Wire-bond</td>
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<tr>
<td>WBG</td>
<td>Wide Band Gap</td>
</tr>
<tr>
<td>WE</td>
<td>Wearables</td>
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<tr>
<td>WiFi</td>
<td>Wireless Fidelity</td>
</tr>
<tr>
<td>WLCSP</td>
<td>Wafer Level Chip Scale Package</td>
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<tr>
<td>WLP</td>
<td>Wafer-Level packaging</td>
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Combined: a combination of flip-chip, wire-bond, fan-out, and embedded die technologies are covered in this report.
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  - Definition and focus
  - Market forecasts
    - Package units (Mu)
    - Wafer volume (kwspy)
    - Revenue ($M)
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    - Integration capabilities
  - Supply chain
    - Fan-out packaging - timeline and evolution
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    - Key players that commercialized FO SiP
    - FO SiP supply chain analysis
  - Market share
    - 2019 FO SiP market share
    - Fo SiP market - player analysis
  - Technology trends
    - FO SiP wafer-volume production - roadmap
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    - Commercialized fan-out SiP products
  - Adoption challenge
  - Chapter conclusion

- **Embedded die: System-in-Package**
  - Definition and focus
  - Introduction
  - Market forecasts
    - Revenue (value)
    - Package (units)
  - Market trends
    - Roadmaps, market drivers, and technical requirements
  - Supply chain
    - Players involved in an embedded die activity
    - Supply chain analysis - business model
  - Technology trends
    - Segmentation (technology features and players’ activities)
    - Adoption rationale
    - Available commercial products, and future product launches
  - Chapter conclusion

- **Conclusion**
- **Yole corporate presentation**
This report’s main objectives are to:

- Describe technologies that can be classified as “System-in-Package”
- Identify and detail the System-in-Package platform’s key process steps
- Analyze the supply chain for System-in-Package technologies
- For these steps, provide a market forecast for the coming years and a prediction of future trends

System-in-Package is studied from the following perspectives:

- Available technologies and their inherent challenges
- Market size
- Revenue and market valuation
- Market share of players involved
- Supply chain analysis
REPORT OBJECTIVES

Advanced System-in-Package (SiP) 2021 is a new report that explores in detail the hottest trends in advanced semiconductor packaging. The report’s objectives are as follows:

• A three-page summary providing an overview of this report’s main points
• Provide a market forecast for System-in-Package revenue (2020 - 2026)
  • Focus on flip-chip, wire-bond, fan-out, and embedded die
  • Explanation of growth for end-markets and end-devices
• Market trends
  • Key drivers, by technology
  • Drivers, by end-market
• Market share
  • Breakdown, by manufacturer
• Furnish a full supply-chain analysis of SiP players
  • SiP manufacturers & key customers
  • SiP business models - full analysis
• Technology trends for SiP technologies
  • By end-market
  • Technical roadmaps
Yole’s market forecast model is based on the matching of several sources:

**Comparison with existing data**
- Monitoring of corporate communication
- Using other market research data
- Yole analysis (consensus or not)

**Comparison with prior Yole reports**
- Recursive improvement of dataset
- Customer feedback

---

**Top-to-bottom approach**
- Aggregate of market forecasts
  - @ System level

**Bottom-up approach**
- Ecosystem analysis
  - Aggregate of all players’ revenue
  - @ System level

**Top-to-bottom approach**
- Aggregate of market forecast
  - @ Semiconductor device level

**Bottom-up approach**
- Ecosystem analysis
  - Aggregate of key players’ revenues
  - @ Semiconductor device level

---

**Market**
- Volume (in Munits)
- ASP (in $)
- Revenue (in $M)

---

**Preexisting information**

**Primary data**
- Reverse costing
- Patent analysis
- Annual reports
- Direct interviews

**Secondary data**
- Press releases
- Industry organization reports
- Conferences

**Information Aggregation**
ABOUT THE AUTHORS

Biographies & contact

VAIBHAV TRIVEDI
Vaibhav Trivedi is a Sr. Technology and Market Analyst in the Semiconductor & Software division at Yole Développement, part of Yole Group of Companies. Based in the US, he is a member of Yole’s advanced packaging team and contributes to analysis of ever-changing advanced packaging technologies. Vaibhav has 17+ years of field experience in semiconductor processing and semiconductor supply chain, specifically on memory and thermal component sourcing and advanced packaging such as SiP and WLP. Vaibhav has held multiple technical and commercial lead roles at various semiconductor corporations prior to joining Yole.

vaibhav.trivedi@yole.fr

FAVIER SHOO
Favier Shoo is a Team Lead Technology and Market Analyst in the Semiconductor & Software division at Yole Développement (Yole), part of Yole Group of Companies. Based in Singapore, he is engaged in the development of reports as well as the production of custom consulting projects. With prior experience at Applied Materials and REC Solar, Favier has developed a deep understanding of the supply chain and core business values. Being knowledgeable in this field, Favier has conducted professional training for industry players and obtained two patents. He also co-founded a startup company. Favier holds a bachelor’s in Materials Engineering (Hons) and a minor in Entrepreneurship from Nanyang Technological University (NTU) (Singapore).

favier.shoo@yole.fr
COMPANIES CITED IN THIS REPORT


Non-exhaustive list
WHO SHOULD BE INTERESTED IN THIS REPORT?

- **Equipment and materials suppliers:**
  - Understand the overall SiP business and technology trends
  - Identify SiP’s high-growth areas
  - Spot business opportunities and prospects
  - See the positioning and market share of various tool suppliers
  - Monitor and benchmark potential competitors

- **OSATs, IDMs, foundries:**
  - Grasp technology trends related to SiP
  - Find new opportunities and define diversification strategies
  - Comprehend the overall SiP market
  - Monitor and benchmark potential competitors
  - Discern the supply chains involved in SiP

- **R&D players:**
  - Obtain insight into the latest developments in SiP technologies
  - Grasp the market potential of different emerging technologies

- **Financial and strategic investors:**
  - Distinguish the key players involved in SiP business
  - See which markets have the highest growth potential, and how the SiP supply chain involved in these segments will benefit
  - Explore M&A opportunities

- **OEMs and integrators:**
  - Highlight technology trends in SiP
  - Confirm new opportunities and define diversification strategies
  - Realize the overall SiP market
  - Monitor and benchmark potential competitors
Various advanced packaging technologies support active and passive component integration for SiP.
Leverage IC assembly/packaging & SMT technologies.

Increased Cost and higher capability
Various process modules used in SiP assembly.
WHY SiP?

<table>
<thead>
<tr>
<th>Benefit</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>More flexibility for system designers</td>
<td>To mix &amp; match IC technologies, optimize performance of each functional block, and reduce cost. Fully integrated SiP solutions enable designers to implement additional functionalities like Bluetooth or camera modules into a system, with minimal design effort.</td>
</tr>
<tr>
<td>Faster time to market</td>
<td>Compared with SoC, different RF components are fabricated at different nodes in various fabs. Time to market reduced.</td>
</tr>
<tr>
<td>Reduce motherboard complexity</td>
<td>By migrating signal routing complexity to the package substrate =&gt; Reduced layer count in motherboard, simplifies product design.</td>
</tr>
<tr>
<td>Better performance</td>
<td>Various ICs &amp; passives placed close together =&gt; shorter line length =&gt; lower R,L,C losses =&gt; Higher signal integrity &amp; reduced power consumption.</td>
</tr>
<tr>
<td>Lower system cost</td>
<td>Compared to discrete packages, optimized SiP solutions result in overall system cost reduction.</td>
</tr>
<tr>
<td>Small form-factor</td>
<td>Sub-system size reduced by integrating multiple dies &amp; passives in single SiP.</td>
</tr>
<tr>
<td>Reliability</td>
<td>Better solder joint compared to the discrete components assembled on board/PCB because the SiPs are molded, which alleviates stress in the joints.</td>
</tr>
</tbody>
</table>

SiP supports the semiconductor industry’s “MtM” heterogeneous integration roadmap.
SiP's biggest market is mobile & consumer. Primarily smartphones & 5G deployment with RF SiP are driving the volume as thinner, denser, and smaller remains the trend.
Flip-chip and wire-bond SiP are the most prevalent SiP types, and the most used in the industry. FO & ED SiPs are still relatively new, used in fewer markets and less applications.
SiP packaging revenue will exceed $19B in 2026, with a CAGR of 5%.
More than 90% of SiP packaging revenue comes from FC/WB SiP packages. However, the highest SiP growth is attributed to ED, which is still a nascent technology entering different markets.
For the next five years, wearables, Wi-Fi routers, and IoT will enjoy significant growth in the SiP market space. The main drivers behind this growth are 5G and sensors.

Wearable remains a key growth driver at 14% CAGR from 2020-2026 as smartwatches and smartearbuds applications usage start to skyrocket and is becoming a main growth segment replacing smartphone in terms of growth contribution.

However, smartphones and RF SiP packages remain key contributor to SiP growth due to 5G deployment and new package design usage such as antenna in package using more “value add” services such as higher component count, double-sided mold, compartmental and conformal shielding.

PC remains on a slow growth trajectory but in short-terms its expected to enjoy higher than “usual” growth due to pandemic work from home models.
MARKET TRENDS - EXPLANATION OF SIP GROWTH

All other markets - SiP growth analysis, by end-device

- **Telecom & Infrastructure** SiP includes markets such as datacenters, and base stations. These are high end complex high density substrate packages such as 2.5D solutions with Si Interposer and HBM stack. Intel also plans to introduce its hybrid packaging line-up of Co-EMIB starting 2023 with 7 nm Si solutions.

- For **automotive & transportation**, ADAS and infotainment are the main drivers. Although camera is a very small portion, its growth is the highest, with expected SiP platforms adopted for ADAS mono, stereo, and triple. Also, computing power is needed for VPU and infotainment. The bulk of it is MEMS & sensors, which compromises applications like pressure, IMUs, optical MEMS, microbolometers, oscillators, and environmental sensors.

- For **other markets** such as medical, industrial, and defense & aerospace, SiP’s size is significantly smaller - although growth is reasonably strong in robotics and IoT-related applications.

### 2020 SIP ALL OTHER MARKETS SPLIT BY END DEVICES ($M, %)

- **Telecom & Infrastructure**
  - Base stations
  - Servers
- **Automotive & Transportation**
  - Camera
  - Computing
  - MEMS & Sensors
- **Medical**
  - Medical Robotics
- **Industrial**
  - Industrial IoTs
- **Defense & Aerospace**
  - Headset/Battlefield equipments
- **TOTAL**
  - As listed above

### 2026 SIP ALL OTHER MARKETS SPLIT BY END DEVICES ($M, %)

- **Telecom & Infrastructure**
  - Base stations
  - Servers
- **Automotive & Transportation**
  - Camera
  - Computing
  - MEMS & Sensors
- **Medical**
  - Medical Robotics
- **Industrial**
  - Industrial IoTs
- **Defense & Aerospace**
  - Headset/Battlefield equipments
- **TOTAL**
  - As listed above

“Others” includes medical, industrial, and defense & aerospace.
2020 total SiP market share: $13.8B
Packaging revenue, split by SiP manufacturer* [%]

*Estimated Market Share Breakdown
*Data is generated by secondary research and revised through interviews
*Others include UTAC, SK Hynix, Nepes, Chipbond etc.
# SUPPLY CHAIN - SIP MANUFACTURERS & KEY CUSTOMERS

<table>
<thead>
<tr>
<th>SIP Manufacturers</th>
<th>TSMC</th>
<th>Intel</th>
<th>Skyworks</th>
<th>SONY</th>
<th>ASE Group</th>
<th>Amkor</th>
<th>Chipbond</th>
<th>ChipMOS</th>
<th>Huatian</th>
<th>Inari Technology</th>
<th>JCET Group</th>
<th>PTI</th>
<th>ShunSin</th>
<th>SPIL</th>
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<th>UTAC</th>
<th>SEMCO</th>
<th>Shinko</th>
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Non-exhaustive list of players

*Substrate Manufacturers with Advanced Packaging Capabilities

System-in-Package Technology 2021 | Sample | www.yole.fr | ©2021
# Samsung’s Advanced Packaging Technology Roadmap

**High-end Packaging Technology Evolution: Towards System-in-Package**

<table>
<thead>
<tr>
<th>Year</th>
<th>Technology</th>
<th>PC Era</th>
<th>Mobile Era</th>
<th>AI/IoT Era</th>
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<td>1990</td>
<td>PKG + PCB</td>
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<td>2000</td>
<td>PKG on PKG</td>
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<td>2017</td>
<td>Si Interposer</td>
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<td>2022</td>
<td>3D-SiP</td>
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**Chip-to-chip Distance**
- >10 mm
- ~1 mm
- ~0.1 mm
- ~0.01 mm

**I/O Density [#/mm²]**
- ~1
- ~10
- ~200
- ~400

Source: Samsung Foundry
FC & WB SIP SUPPLY CHAIN - KNOWN BUSINESS MODELS

Non-Exhaustive List of Activities
ANTENNA SYSTEM-IN-PACKAGE EVOLUTION IN SMARTPHONE

From outside antenna to antenna “case”, or antenna-on-PCB to antenna-in-package

1992

Antenna outside phone body

2G (GSM)

3G (WCDMA)

1992

Antenna “on case”

2007

Antenna on flex

4G (LTE)/5G Sub 6GHz

2014

Antenna in package

5G (mmWave)

2019
Fan-Out WLP and PLP Applications and Technologies 2021

Status of the Advanced Packaging Industry 2020

5G Packaging Trends for Smartphones 2021

Advanced Packaging Quarterly Market Monitor

Contact our Sales Team for more information
HiSilicon Hi1382 Coherent Processor with ASE’s FOCoS

Advanced System-in-Package Technology in Apple’s AirPods Pro

NVIDIA A100 Ampere GPU
HOW TO USE OUR DATA?

Yole Group of Companies, including Yole Développement, System Plus Consulting and PISEO, are pleased to provide you a glimpse of our accumulated knowledge.

We invite you to share our data with your own network, within your presentations, press releases, dedicated articles and more, but you first need approval from Yole Public Relations department.

If you are interested, feel free to contact us right now!

We will also be more than happy to give you updated data and appropriate formats.

Your contact: Sandrine Leroy, Dir. Public Relations
Email: leroy@yole.fr
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- Imaging
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- Display

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- Semiconductor Manufacturing
- Memory
- Computing and Software

Power & Wireless
- RF Devices & Technologies
- Compound Semiconductors & Emerging Materials
- Power Electronics
- Batteries & Energy Management
REPORTS, MONITORS & TRACKS

India and RoA
Takashi Onozawa - takashi.onozawa@yole.fr
+81 80 4371 4887

Greater China
Mavis Wang - mavis.wang@yole.fr
+886 979 336 809 +86 136 6156 6824

Korea
Peter Ok - peter.ok@yole.fr
+82 10 4089 0233

Japan
Miho Ohtake - miho.ohtake@yole.fr
+81 34 4059 204

Japan and Singapore
Itsuyo Oshiba - itsuyo.oshiba@yole.fr
+81 80 3577 3042

Japan
Toru Hosaka - toru.hosaka@yole.fr
+81 90 1775 3866

FINANCIAL SERVICES
› Jean-Christophe Eloy - eloy@yole.fr
  +33 4 72 83 01 80

› Ivan Donaldson - ivan.donaldson@yole.fr
  +1 208 850 3914

CUSTOM PROJECT SERVICES
› Jérome Azémard, Yole Développement - jerome.azemar@yole.fr
  +33 6 27 68 69 33

› Julie Coulon, System Plus Consulting - jcoulon@systemplus.fr
  +33 2 72 17 89 85

GENERAL
› Sandrine Leroy, Public Relations - sandrine.leroy@yole.fr
  +33 4 72 83 01 89

› General inquiries: info@yole.fr - +33 4 72 83 01 80

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