

System in Package

Semiconductor industry demands for higher levels of integration and lower costs coupled with a growing awareness of complete system configuration have continued to drive the popularity of System in Package (SiP) solutions. Amkor's SiP state-of-art design rules is an ideal solution in markets that demand miniaturization with increased functionality. By assembling, testing and shipping millions of SiP devices per day, Amkor Technology has a proven track record as the industry leader in SiP design, assembly and test.

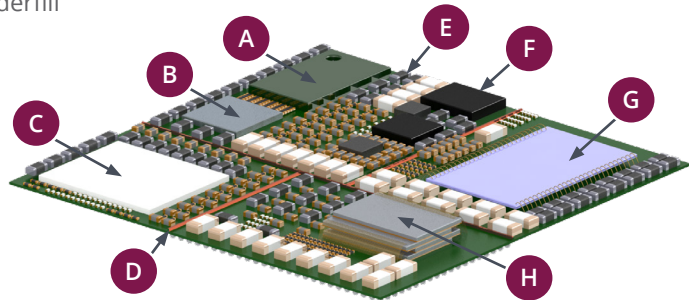
APPLICATIONS

- ▶ RF and wireless devices
 - ▷ Power amplifiers, front-end module, antenna switch, cellular handset, cellular infrastructure, 5G NR, Sub-6 GHz, mmWave and Antenna in Package (AiP/AoP)
- ▶ IoT, wearables/hearables and Machine to Machine (M2M)
 - ▷ BLTe, Wi-Fi, UWB, LTE-M & NB-IoT; controller and mixed-mode devices
- ▶ Automotive applications
 - ▷ Infotainment and sensory modules
- ▶ Power modules
 - ▷ DC/DC converter, PMIC, battery management and others
- ▶ Computing and networking
 - ▷ 5G networking, infrastructure and data center

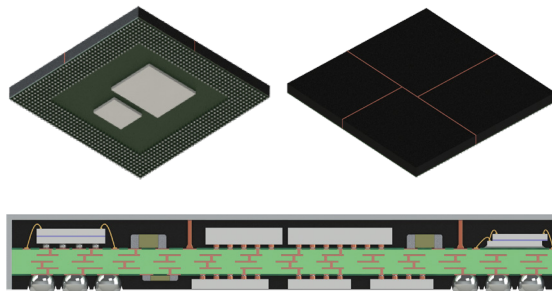
What Is a System in Package?

Amkor Technology defines advanced SiPs as multi-component, multi-function products in an IC package. They require high-precision assembly technologies, which leverage Amkor's strengths.

- ▶ Size reduction & ultra-thin package
- ▶ Thin substrate with core and coreless using finer line and spacing
- ▶ Conformal and compartmental shielding
- ▶ Low filler size for mold underfill
- ▶ Fine pitch flip chip and copper pillar
- ▶ Double side assembly
- ▶ Test development and production test
- ▶ Turnkey solution
- ▶ Manufacturing excellence



- A MEMS
- B WLCSP
- C Flip chip
- D Compartmental shielding
- E Passive components
- F Pre-packaged
- G Wirebond
- H Stacked die



Top and bottom side assembly, molding, conformal and compartmental shielding

System in Package Technology

Markets for System in Package

System in Package technology allows multiple advanced packaging technologies to be combined to create solutions customized to each end application. Laminate-based SiP technology is a front runner solution and the most popular SiP solution for cellular, IoT, power, automotive, networking and computing system integrations.



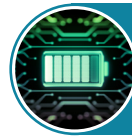
Mobility



IoT



Automotive



Power Management



Mixed-Mode Technology

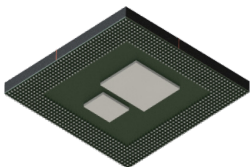
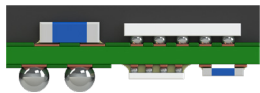


Computer & Networking

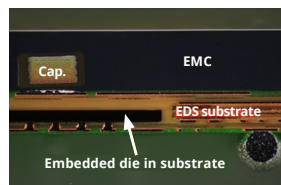
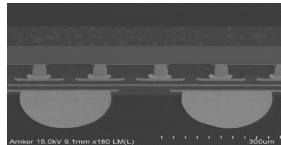
SiP Platforms and Solutions

Amkor's emphasis is on functional integration and size reduction by using different package form factors and interconnect technologies, including:

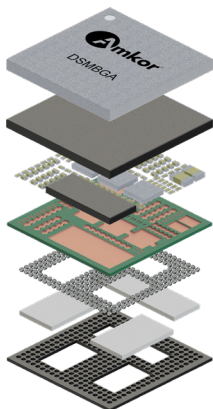
- ▶ Double sided assembly DSBGA



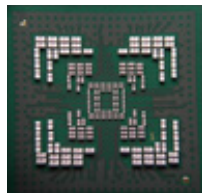
- ▶ Embedded passive & active components



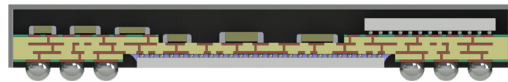
- ▶ Double sided mold DSMBGA



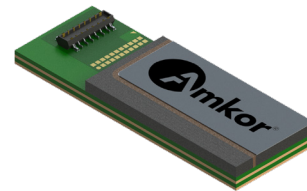
- ▶ Passive components (01005, 008004)



- ▶ Thin substrate, core and coreless substrate, recessed and cavity substrate

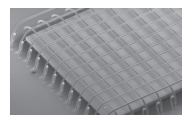


- ▶ Partial molding and partial conformal shielding
 - ▷ Connector, antenna and partial mold & shield

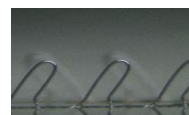


- ▶ Sputtering conformal shielding and compartmental conformal shielding

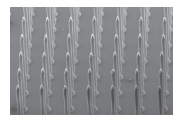
- ▷ Amkor developed an exceptional sputtering shielding technology to solve electromagnetic radiation effects among electronic components within SiP components and surrounding environment with excellent electrical and magnetic shielding performance
- ▷ Compartment shielding with Cu wire
 - » Wire cage
 - » Wire fence
 - » Vertical wire



Wire cage



Wire fence



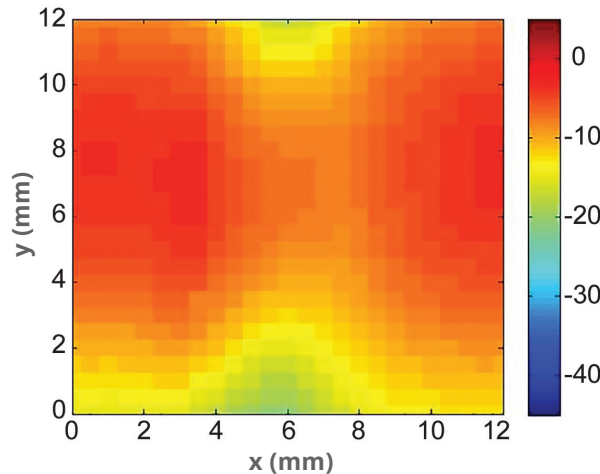
Vertical wire

System in Package Technology

Near Field Conformal Shielding Performance Measurements From 100 MHz to 6 GHz

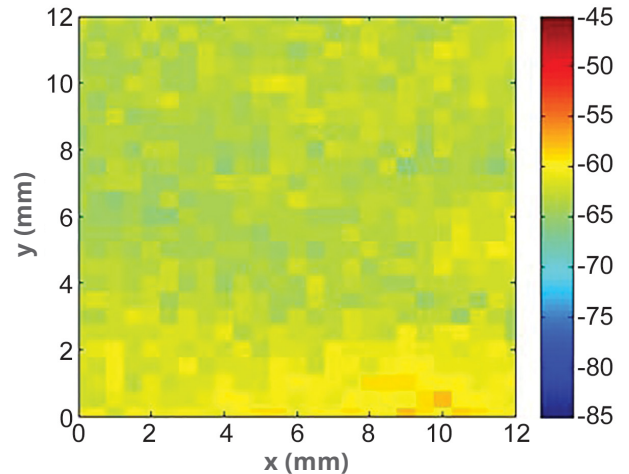
Unshielded SiP

Unshielded DUT - Ex magnitude maximum radiation



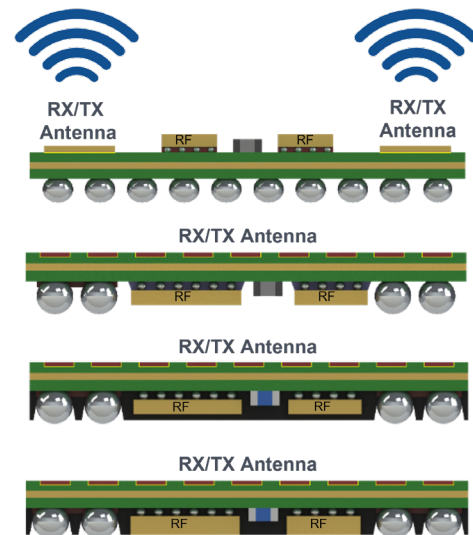
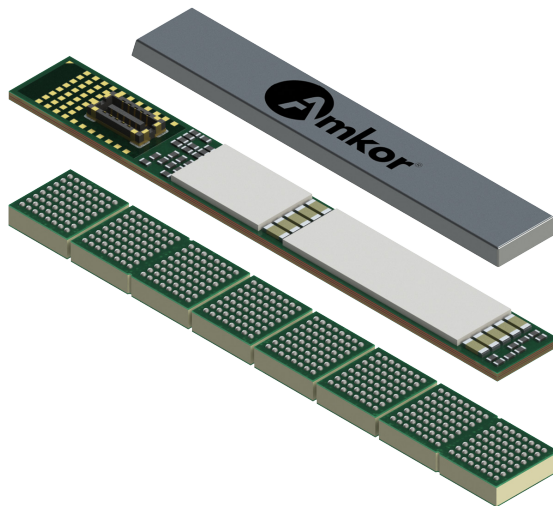
SiP With Sputter Conformal Shielding

3 μm Cu - Ex maximum radiation



AiP/AoP (5G NR) SiP Solutions

Millimeter wave radio design with beam forming and array antenna will be used in varieties of advanced SiP products for 5G cellular system. Millimeter electromagnetic wave design is imposing a new challenge for the system designers, components and SiP packaging engineers.



Key Amkor Packaging Technologies for AiP/AoP

- ▶ Greater than 40 GHz achieved
- ▶ Compartmental shielding using vertical and gage wires
- ▶ Partial (selective) conformal shielding
- ▶ Partial molding
- ▶ Substrate layer counts: Up to 14 layers
- ▶ Low loss and low dielectric constant substrate

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Thermal Mechanical and Electromagnetic Characterization and Design Considerations

- ▶ Warpage optimization
 - ▷ Module level and strip level warpage
 - ▷ Warpage at room temperature and reflow temperature
- ▶ Stress analysis
- ▶ Die, bump, substrate stress analysis
- ▶ Correlate to FA to help root cause analysis and correction options
- ▶ BLR characterization
- ▶ Board level temperature cycle life performance prediction
- ▶ Die attach delamination stress analysis
- ▶ Material properties measurements including CTE, modulus, Tg, Theta JA, Theta JB and Theta JC
- ▶ Accelerated failure testing
- ▶ Electromigration as function of temperature, time current and interconnect
- ▶ Bend and drop testing
- ▶ Die strength and stress
- ▶ Surface mount assembly support
- ▶ Failure and reliability analysis
- ▶ Thermal simulation and air flow effects

Advanced SiP Testing

As part of its complete SiP design solution, Amkor has developed expertise in RF and digital testing, including test system software/hardware development and manufacturing test.

- ▶ Comprehensive test services that complement wafer level and package assembly
- ▶ Amkor is the #1 RF test services supplier for Sub-6 GHz
- ▶ Ongoing joint efforts with test equipment suppliers and customers to enable 5G product production testing
- ▶ Amkor has a vast array of test capabilities and rich experience in device testing
- ▶ Offers an extensive equipment fleet and continues to invest in new capabilities required to test the latest devices

System in Package Technology

Manufacturing Excellence

- ▶ Amkor's Center of Excellence for substrate-based SiP technology is located in our largest volume manufacturing facility in K4 Gwangju, South Korea
- ▶ The large-scale manufacturing capabilities in K4 factory can achieve significant volume production support with very high yields with short cycle times
- ▶ Latest advanced technology that supports high speed, high-accuracy chip and component placement
- ▶ Amkor's SiP design rules are the most advanced in the industry and are available to customers through a web portal access system
- ▶ Amkor production lines have full automation, in-line inspection, RFID control and other process control methods to ensure the highest yields and quality while minimizing any potential loss of bill of material (BOM) components
- ▶ Ultra-high-speed SMT placement machines with leading-edge component placement accuracy for best quality and lowest cost
- ▶ Flexible placement machines are ideally suited for odd-form component placement
- ▶ Capability to place any common component format available in tape and reel format down to and including the smallest 008004 size
- ▶ Capability of mounting bumped die directly from wafer tape
- ▶ Support for solder paste stencil printing, flux stencil printing or flux dipping processes
- ▶ Automated 100% in-line optical inspection of solder paste to reduce BOM component loss
- ▶ Support for all common RoHS/Green compliant solder alloys
- ▶ Amkor supports Engineering Build Requests (EBRs) on dedicated rapid-turn "New Product Introduction" lines
 - ▷ The lines are exactly the same as the high-volume manufacturing lines
 - ▷ Seamless NPI transfer to production
 - ▷ Large number of rapid-turn EBRs to facilitate RF tuning of the parts
 - ▷ Close collaborative process with customers

Supply Chain Management

Supply chain considerations play a major factor in the success of SiP product realization and impact both design and manufacturing. To optimize the complete SiP process, Amkor has expanded its traditional supply chain expertise into passive components, and other parts not traditionally found in the package assembly environment. As a result, Amkor can manage the supply chain to ensure successful SiP development and production.

SiP Technologies From Amkor

System in Package is the modular design approach offering unprecedented flexibility in product development. The end user benefits from a faster time-to-market include reduced cycle times for system design, lower development risk compared to SoC IC development, flexibility, tuned functional performance, and, ultimately, a lower overall cost of ownership.

Amkor has developed an extensive toolset to maximize circuit density and address the sophisticated packaging formats required to productize 5G applications – such as double-sided assembly, embedded die in substrate, thin film RDL & dielectrics, and various types of RF shielding. This toolset, combined with extensive SiP capacity and AiP/AoP technology, uniquely positions Amkor to serve customers who want to outsource the challenges and high investment associated with combining multiple ICs with advanced package assembly and test technologies for 5G networks.

Amkor's SiP technology is an ideal solution in markets that demand smaller size with increased functionality. By assembling, testing and shipping more than one million SiP devices per day, Amkor Technology has a proven track record as the industry leader in SiP design, assembly and test. Contact Amkor today and let us add you to our growing list of customers enjoying success with System in Package technology.



Visit amkor.com or email sales@amkor.com for more information.



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