

Antenna in Package (AiP) Antenna on Package (AoP)

Amkor is the first OSAT to deliver High Volume Manufacturing (HVM) of products using AiP/AoP technology.

Amkor's cutting-edge AiP and AoP technology has already been deployed and offers fully-integrated 5G NR millimeter wave (mmWave) and sub-6 GHz RF modules for smartphones and other mobile devices. These mmWave antenna modules deliver capabilities across several spectrum bands, in a very compact footprint that is well suited for integration in mobile devices.

To date, mmWave signals had not previously been used for mobile wireless communications due to many technical and implementation challenges, that impact nearly every facet of device engineering, including materials, form factor, industrial design, thermal performance and regulatory requirements for radiated power. Successful implementation of these types of antenna solutions, spanning both mmWave and sub-6 spectrum bands for 5G, will transform the mobile industry and consumer experience.

In addition to its extensive System in Package (SiP) capacity and AiP/AoP technology, 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 expertise in RF and antenna package design, 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.

As demand for packages that support 5G starts to ramp up, Amkor is already well underway with the successful implementation of AiP and AoP technology.

Key Amkor Packaging Technologies for AiP/AoP

- ▶ Achieved over 26 GHz
- ▶ Compartmental shielding using vertical wire and wire fence technologies
- ▶ Partial (selective) conformal shielding
- ▶ Partial molding
- ▶ Body size: up to 29.0 mm x 4.0 mm
- ▶ Substrate layer counts: up to 14 layers
- ▶ Thin-film RDL and dielectrics for 77 GHz and above

AiP/AoP

Why AiP/AoP? What Are the Benefits to Smartphones?

AiP/AoP improves 5G signal integrity and overcomes the challenges below, using small footprint-phased antenna array design and minimizing the space required to support mmWave inside 5G devices.

Technical Challenges Addressed by AiP/AoP

- ▶ Propagation: High mmWave frequencies experience higher path loss and attenuation, so signals don't travel very far
- ▶ Range: mmWave signals are easily blocked by objects
- ▶ Size: mmWave typically requires an array of antenna elements to help overcome these issues, thereby increasing the footprint inside a device

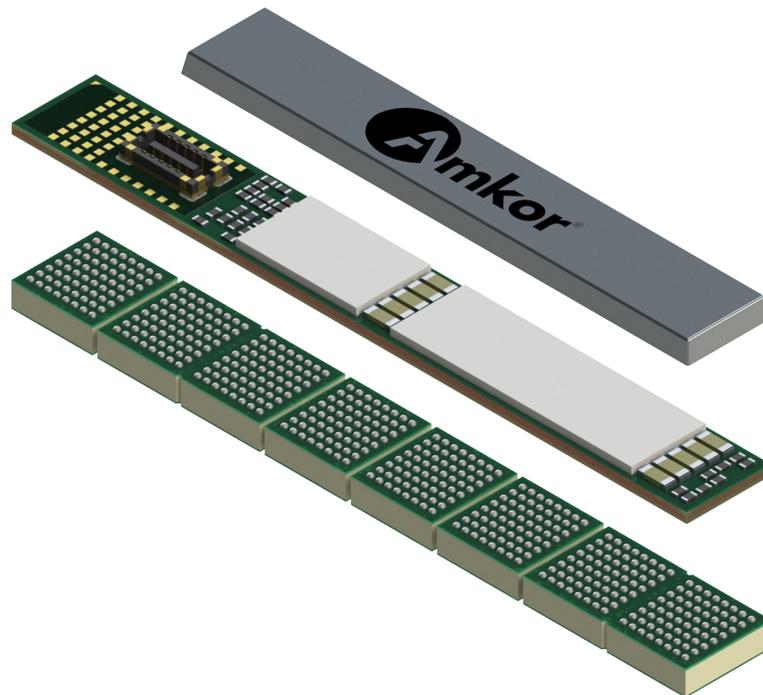
5G Market Challenges

Market Requirements

- ▶ Introduction of mmWave frequencies
- ▶ Higher demands on power consumption
- ▶ Extended RF component counts
- ▶ mmWave testing

Amkor Offers

- ▶ Advanced multi-die integration toolbox
- ▶ RF SiP design and simulation know-how
- ▶ Extensive fCSP, WLCSP and WLFO portfolios
- ▶ Established and reliable supply chain
- ▶ Global assembly scale and test investments



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