YOLE Développement

Press Release
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LYON, France

5G: advanced packaging technologies bring innovation[1]

5G packaging brings innovative technology and new opportunities for SiP business.

OUTLINE:

- Market forecasts:
  5G packaging market will grow to US$2.6 billion in 2026, with 31% CAGR[2].
  The mobile market segment will reach about US$4.3 billion in 2026, with 24% CAGR.
- Technology trends:
  RFFEMs[3] supporting 5G sub-6 GHz utilize modifications of existing flip-chip laminate-based SiPs[4] with a similar bill of materials: incremental innovation.
  5G mmW brings disruptive packaging with the entry of new packaging architectures and platforms: fan-Out WLP[5] and glass substrate interposers competing with advanced organic substrate flip-chip packages with new low-loss dielectrics.
  Various packaging solutions based on flip-chip & fan-out technology with different architectures is proposed for integrating antenna elements with RF[6] components for 5G mmW communication.
- Supply chain:
  IDMs such as Qorvo, Broadcom (Avago), Skyworks and Murata who are key players for RF components, do assembly internally as well as outsource it.
  Qualcomm emerged as a serious RF front-end player for 5G solutions, especially 5G mmWave.
  As a fabless company, Qualcomm outsources all its SiP assembly, which results in more business opportunities for OSATs.
- **SYNAPS 2021** - Symposium by Yole Développement and NCAP on Advanced Packaging for Semiconductors: From May 18-20. More info.

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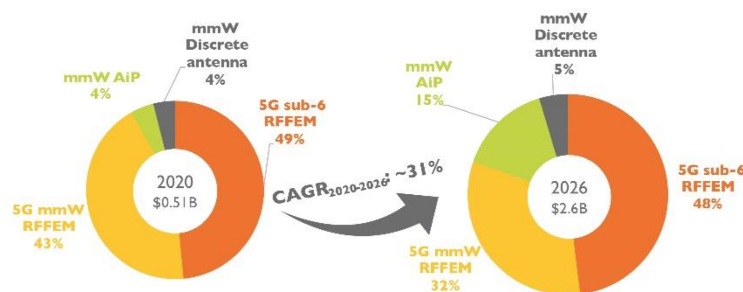
[1] Extracted from:
5G Packaging Trends for Smartphones report, Yole Développement, 2021
RF Front-End Module Comparison 2021 – Vol. 2 – Focus on 5G Chipset, System Plus Consulting, 2021
5G's Impact on RF Front-End and Connectivity for Cellphones 2020, Yole Développement, 2020
[2] CAGR: Compound Annual Growth Rate
[3] RFFEM: Radio Frequency Front-End Module
[4] SiP: System-in Package
[5] WLP: Wafer-level Packaging
[6] RF: Radio Frequency

"The RF components in the mobile are packaged at two levels," asserts **Santosh Kumar, Principal Analyst & Director Packaging, Assembly & Substrates, Yole Korea at Yole Développement (Yole).**: *"The 1st-level packaging of various RF components like filters, switches, and amplifiers at die/wafer level, includes RDL[7], TSV[8], and/ or bumping steps. Then the 2nd-level SiP packaging is performed at the SMT[9] level where various components are assembled on SiP substrate along with passives."*

The 5G packaging market was US$0.52 billion in 2020 and is expected to grow at 31% CAGR to reach ~US$2.6 billion in 2026. The 5G packaging includes the RF modules with PAD, DRx FEM, etc. and AiP[10] for 5G sub-6 GHz & 5G mmW connectivity.

5G packaging market forecast for smartphone – Breakdown by RF Front-End modules & mmW antenna

(Source: 5G Packaging Trends for Smartphones report, Yole Développement, 2021)



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In this context, the market research and strategy consulting company, Yole and its partner System Plus Consulting investigates disruptive advanced packaging and RF electronics technologies and related markets in depth, to point out the latest innovations and underline 5G business opportunities.

Released today, the 5G Packaging Trends for Smartphones is a new Yole's report which focuses on both the module and component packaging for 5G Sub-6GHz and 5G mmWave.

This study reveals in detail the 5G packaging market for smartphones and covers various RF front-end modules to support 5G communication, such as: 5G sub-6GHz RFFEM (PAMiD[11], DRx), 5G mmW AiP, 5G mmW discrete antenna, 5G mmW FEM[12].

What is the status of the 5G packaging technologies for smartphones? What are the economic and technical challenges? What are the opportunities and the key market drivers? Who are the suppliers to watch, and what innovative technologies are they working on?

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[7] RDL: Redistribution Layers
[8] TSV: Through Silicon Via
[9] SMT: Surface Mount Technology
[10] AiP: Antenna in Package
[11] PAMiD: Power-Amplifier Module with integrated duplexers
[12] FEM: Front-End Module

Press Release

Yole presents today its vision of the 5G packaging industry for smartphones.

As analyzed by Yole's team in the new 5G Packaging Trends for Smartphones report, 5G sub-6 GHz RFFEM accounts for 67% of the total 5G packaging in 2026, followed by 5G mmW FEM, mmW AiP, and mmW discrete antenna.

In parallel, the AiP assembly market for mmW communication in mobile will grow by 40% to reach about US$448 million in 2026. AiP's market share in the 5G packaging market will increase from 11% in 2020 to 17% by 2026.

In addition, 5G packaging substrate market will grow at CAGR ~35% to reach ~US$721 million in 2026. Low-loss substrate is essential to support 5G mmWave mobile communication and is required for the mmWave SiP, including AiP & discrete antenna.

According to **Cédric Malaquin, Technology & Market Analyst, RF devices & technologies within the Power & Wireless division at Yole**: *"With the 5G specification, the number of RF paths has dramatically increased for both the downlink and the uplink. As a result, more dies or a larger one is needed to accommodate 5G signals along with 4G and other radios.*

As board space saving is key to the smartphone industry, RF Front End tier 1s such as Murata, Skyworks, Qorvo, Broadcom, and Qualcomm, along with OSAT companies, have been even more creative to enable component packing in sophisticated modules."

In, the RF Front-End Module Comparison 2021 – Vol. 2 – Focus on 5G Chipset report released also today, the **Senior Technology and Cost Analyst from System Plus Consulting, Stéphane Elisabeth, PhD.** adds: *"Based on our extensive database from 2020, the supplier rankings in terms of cost show the leadership of Qualcomm, followed by Broadcom and Qorvo, in the RF Front End for 5G phones. Almost half of the RFFE revenue per smartphone goes to Qualcomm. However, in the early 2021 5G phones, Qorvo has started the race for second place with some innovative modules that could disrupt the ranking."*

5G packaging supply chain

(Source: 5G Packaging Trends for Smartphones report, Yole Développement, 2021)

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The various RF active & passive components in mobile are assembled in the SiP or remain discretes. LTE evolution has led to complex architecture in mobile phones, mainly due to carrier aggregation. Meanwhile, RF's board area and available antenna space have been reduced, leading to a densification trend that sees more handset OEM[13]s adopting power amplifier modules and implementing new techniques, i.e., antenna-sharing between LTE[14] and WiFi.

According to **Santosh Kumar**: *"5G added even more complexity requiring more densification in front-end modules to enable 5G sub-6 GHz & mmWave band integration. A single die is cost-efficient for components like tuners or discrete filters. For high-end phones, SiP technology is preferred for performance efficiency".*

Before 2018, LGA SiP was used in the RF industry. 4G LTE in smartphones used multi-die SiP (10-15 dies, utilizing flip-chip balls or Cu pillars or wire-bond to connect various components to the organic coreless substrate) for FEM, as well as for filter banks and diversity receive modules.

BGA has since been widely adopted thanks to the double-side packaging development. As an example, the recent version of the integrated RF SiP (MB/HB PAMiD) in the iPhone 12 is almost 50% smaller than the first mid/high-band PAMiD. Thanks to innovation, such as EMI shielding, Flip-Chip PA[15], or Double Side Molding BGA, Broadcom managed to integrate the same system in a smaller footprint.

Double-side BGA packaging technology brings advances in component density with a new type of internal shielding and isolation of critical components using the PCB substrate. Leading companies like Broadcom, Qorvo and Skyworks implement stepwise innovation in RF SiP, moving from LGA to DSBGA to DS-MBGA, whereas Murata directly implemented DS-MBGA for system integration & miniaturization.

RF system integration & miniaturization trends require innovation at various levels for 5G packaging in mobile. RFFEM supporting 5G sub-6 GHz utilize modifications of existing flip-chip laminate-based SiPs with a similar bill of materials: incremental innovation. On the other hand, 5G mmW brings disruptive packaging with the entry of new packaging architectures and platforms: fan-Out WLP and glass substrate interposers competing with advanced organic substrate flip-chip packages with new low-loss dielectrics.

"Antenna technology and placement is one of the most critical challenges for 5G semiconductor systems," comments **Santosh Kumar**. "*At mmWave frequencies, long paths from semiconductor packages to antennas represent high losses, making it desirable to integrate the antenna into the SiP. Higher frequencies require smaller antennas (mm instead of cm), which, from a footprint point of view, would be easier to integrate into SiPs."* In this context, various packaging solutions based on

[13] OEM: Original Equipment Manufacturer
[14] LTE: Long Term Evolution
[15] PA: Power Amplifier

flip-chip & fan-out technology with different architectures are proposed for integrating antenna elements with RF components for 5G mobile communication.

All year long, Yole Développement and System Plus Consulting publish numerous advanced packaging and RF Electronics reports and monitors. In addition, experts realize various key presentations and organize key conferences.

Semiconductor industry: it is imperative to innovate. Advanced packaging is the path forward…
In this dynamic context and encouraged by 7 consecutive years of successful symposiums that have attracted more than 200 participants on average, Yole and its partner NCAP (National Center for Advanced Packaging) are proud to announce this year again, the online Symposium by Yole Développement and NCAP on Advanced Packaging Semiconductors – SYNAPS. More info.

Make sure to be aware of the latest news coming from the industry and get an overview of our activities, including interviews with leading companies and more on i-Micronews. Stay tuned!

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About our analysts

Santosh Kumar is currently working as Principal Analyst and Director Packaging, Assembly & Substrates for Yole Développement's activities in Korea. Santosh is part of Semiconductor, Memory & Computing division. Based in Seoul, he is involved in the market, technology and strategic analyses of the microelectronic assembly and packaging technologies. His main interest areas are advanced IC packaging technology including equipment & materials. He is the author of several reports on fan-out / fan-in WLP, flip chip, and 3D/2.5D packaging.
Santosh Kumar received the Bachelor's and Master's Degree in Engineering from the Indian Institute of Technology (IIT), Roorkee and University of Seoul respectively.

Favier Shoo is a Team Lead Analyst in the Packaging team within Semiconductor, Memory and Computing Division at Yole Développement (Yole), part of Yole Group of Companies. Based in Singapore, Favier manages an international team and develops the technical expertise and market know-how within the team. Favier also focuses on the production of technology & market reports, conducts strategic consulting and custom studies. Favier holds a Bachelor's in Materials Engineering (Hons) and a Minor in Entrepreneurship from Nanyang Technological University (NTU) (Singapore). Favier was also the co-founder of a startup company where he formulated business goals, revenue models and marketing plans.

Stéphane Elisabeth, PhD is Senior Technology and Cost Analyst at System Plus Consulting, part of Yole Développement (Yole). Stéphane regularly works on numerous reverse engineering and costing reports while also managing custom projects in the RF electronics and advanced packaging fields. His mission at System Plus Consulting is to provide an in-depth understanding of the technologies selected by the leading semiconductor companies as well as the ecosystem around a device.
Stéphane holds an engineering degree in electronics and numerical technology (Université de Nantes, France) as well as a PhD. in Materials for Microelectronics (Université de Nantes, France).

As a Technology & Market Analyst, specialized in RF devices & technologies within the Power & Wireless division at Yole Développement (Yole), **Cédric Malaquin** is involved in the development of technology & market reports as well as the production of custom consulting projects. Prior his mission at Yole, Cédric first served Soitec as a process integration engineer during 9 years, then as an electrical characterization engineer during 6 years. He deeply contributed to FDSOI and RFSOI products characterization.
Cédric graduated from Polytech Lille in France with an engineering degree in microelectronics and material sciences.

Antoine Bonnabel works as a Technology & Market Analyst for the Power & Wireless team of Yole Développement (Yole). He carries out technical, marketing and strategic analyses focused on RF devices, related technologies and markets. Prior to Yole, Antoine was R&D Program Manager for DelfMEMS (FR), a company specializing in RF switches and supervised Intellectual Property and Business Intelligence activities of this company. Antoine holds a M.Sc. in Microelectronics from Grenoble Institute of Technologies (France) and a M.Sc. in Management from Grenoble Graduate School of Business (France).

About the reports

5G Packaging Trends for Smartphones

5G Packaging brings innovative technology and new opportunities for SiP business. – Performed by Yole Développement

Companies cited:

Amkor (J-Devices, Nanium), Acco, Ajinomoto Fine-Techno, Apple, Applied Materials, ASE Group, ASMPT (NEXX), AT&T, AT&S, Avago Technologies, Besi, Broadcom, Cavendish, Daeduck Electronics, Deca Technologies, Dupont, Ericsson, Evatec, Foxconn, and more…

As well as:

- **RF Front-End Module Comparison 2021 – Vol. 2 – Focus on 5G Chipset**

Technical and cost overview of the evolution of radio frequency front-end module technologies integrated in 5G mmWave and Sub-6 GHz Phones. – Performed by System Plus Consulting

- **5G's Impact on RF Front-End and Connectivity for Cellphones 2020**
  An intensifying US-China competition for RF technology supremacy. – Performed by Yole Développement

Related reports:

- 5G's Impact on RF Front-End for Telecom Infrastructure 2021
- Qualcomm's Second Generation 5G mmWave Chipset, from Modem to Antenna
- Broadcom AFEM-8200 PAMiD in the Apple iPhone 12 Series

About Yole Développement

Founded in 1998, Yole Développement (Yole) has grown to become a group of companies providing marketing, technology and strategy consulting, media and corporate finance services, reverse engineering and reverse costing services and well as IP and patent analysis. With a strong focus on emerging applications using silicon and/or micro manufacturing, the Yole group of companies has expanded to include more than 80 collaborators worldwide… More

About System Plus Consulting

System Plus Consulting specializes in the cost analysis of electronics, from semiconductor devices to electronic systems. Created more than 20 years ago, System Plus Consulting has developed a complete range of services, costing tools and reports to deliver in-depth production cost studies and estimate the objective selling price of a product… More

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