



## FOR IMMEDIATE RELEASE:

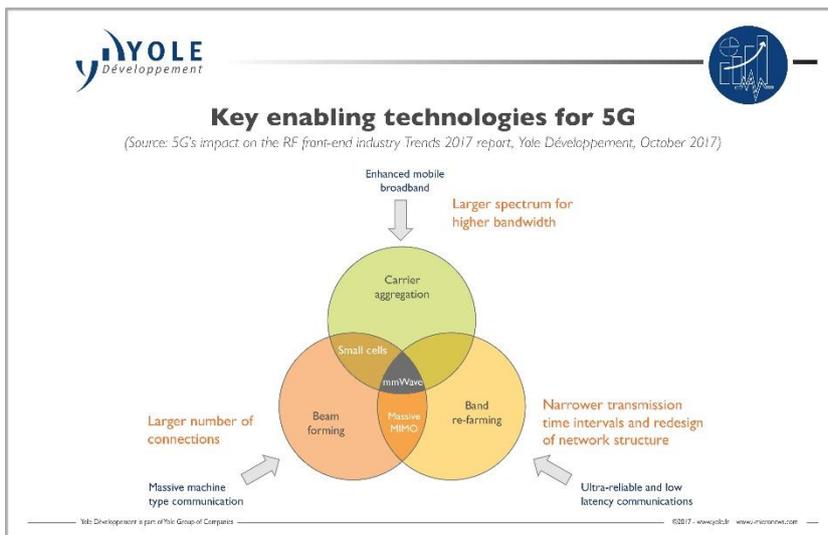
### Emerging 5G wireless communication standard is bringing disruption from services to technology and supply chain

Extracted from: 5G's Impact on the RF Front-End Industry report – Advanced RF System-in-Package for cell phones report - Yole Développement, October 2017

**LYON, France – October 18, 2017:** The 5th generation of cellular networks is anticipated to arrive in the timeframe of the next 2-5 years, enabling Gbps<sup>1</sup> datarates and a plethora of new applications and services. One of the key drivers for developing such speed is high resolution video demand (4K, 8K etc.) over mobile devices. Furthermore, future applications such as mobile driven AR/VR<sup>2</sup> would benefit greatly from such technical capabilities. In addition, certain amounts of data generated by IoT<sup>3</sup> end devices will need to be transmitted over the cellular network as well. Global mobile data traffic is growing at an astonishing rate, with more than 40% CAGR<sup>4</sup> predicted between 2017 and 2022.

Under this dynamic ecosystem, the “More than Moore” research and strategy consulting company [Yole Développement \(Yole\)](#) pursues its investigations towards the RF<sup>5</sup> electronics industry and proposes its vision of the market with two dedicated reports: “[5G's Impact on the RF Front-End Industry](#)” and “[Advanced RF System-in-Package for Cell Phones](#)”. In both technology & market analyses, the company details

the 5G market segmentation and ecosystem, highlighting drivers and dynamics. Yole's analysts offer a detailed overview of the 2015-2025 landscape and forecasts of the RF front-end industry and examine the impact of the 4G to 5G transition. Technology roadmaps, RF front-end industry strategy are part of both reports. The consulting company also analyzes the evolution of the packaging



<sup>1</sup> Gbps : Giga bits per second

<sup>2</sup> AR/VR: Augmented and Virtual Reality

<sup>3</sup> IoT : Internet of Things

<sup>4</sup> CAGR : Compound Annual Growth Rate

<sup>5</sup> RF : Radio Frequency

architectures for cell phone's applications. Yole is expecting more and more disruptive SiP<sup>6</sup> architectures in 5G mmWave.

What are the requirements and challenges due to the 5G arrival? How will wireless infrastructure and cell phone terminals change in the next decade? Which packaging architectures can rise to the occasion?... Yole's analysts offer today a snapshot of the RF front-end industry and 5G revolution.

Today, 5G is more than a dream – it's a hot topic. Every telecom operator, base station manufacturer, small-cell manufacturer, and user-equipment provider is working on 5G, in either one or all three of its aspects:

- 5G for IoT, with frequency below 1 GHz for IoT devices requiring low data rates, along with long-range coverage and at a low cost. Technologies are already available, including short-range radio/WiFi and dedicated networks like SigFox and LoRa.
- 5G Sub-6GHz: with a frequency below 6GHz marking the actual 4G technology's evolution with massive MIMO, more carrier aggregation and more front-end module integration will push the limits of current technologies.
- 5G mmWave possesses a frequency above 10 GHz - typically 28GHz, 39 GHz, or 60 GHz for short-range, high data-rate exchanges. Today, two specific use-cases are observed in the US and Korea: it includes fixed wireless access for Verizon and AT&T in the US. Today, trials are progressing, and deployment phases are scheduled in around 15 US cities. The second case is focused on 5G trial services, that will support the February 2018 Winter Olympics Games in Korea for KT.

*“Both use cases have their own specifications, and their common ground is a 28 GHz spectrum to access wider bandwidth and higher data rate”, explains **Claire Troadec, Activity Leader, RF Electronics at Yole.** And she adds: “Furthermore, in 2019 Qualcomm is committed to bringing a 5G mmWave phone to market. This will require extensive R&D to solve antenna integration issues and devise a 5G mmWave RF front-end that can sustain the cell phone industry's performance, miniaturization, and cost pressures.”*

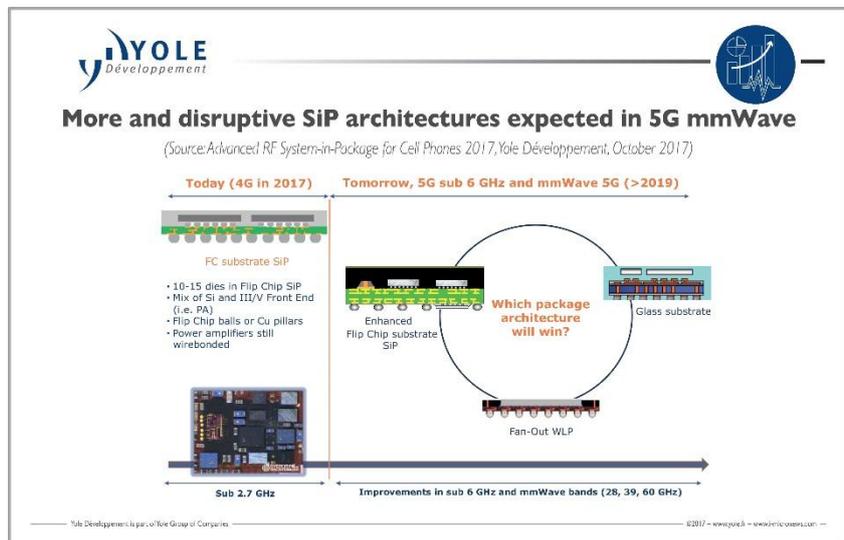
5G mmWave domain is opening completely new sets of requirements that need considerable technology disruptions. At mmWave frequencies, signal path length becomes particularly critical and any design imperfection is transformed into considerable signal losses and deteriorated device performance. *“Today, RF SiPs, namely FEMiD and PAMiD are rather complex and contain 10-15 heterogeneous dies (Si based,*

---

<sup>6</sup> SiP : System-in-Package

III/V, MEMS etc.) with mixed wirebonding, flip chip ball or Cu pillar interconnects attaching to organic package substrates with up to 7 metal layers”, asserts **Andrej Ivankovic, Technology & Market Analyst, Advanced Packaging & Semiconductor Manufacturing at Yole.** “Future 5G sub 6 GHz and especially 5G mmWave will require even denser integration of dies in order to minimize signal paths and keep losses under control.”

Finding new innovative substrate/RDL solutions will directly impact the performance and success of a product. On top of that, integration of the antenna within the SiP is more a need than an option, bringing a set of additional challenges from placement options, processing, shielding etc. Future RF packaging innovation in cellphones is being performed on several levels and in parallel for 5G sub 6GHz and 5G mmWave, however the real packaging disruption is expected on mmWave frequencies >24 GHz. Some of the future RF packaging quests are search for low loss materials, antenna integration, possible integration of dies in front end, overhaul in packaging architectures and exploration of shielding options – all in order to develop new generations of 5G RF System-in-Packages. Investigated packaging platforms for 5G so far include advanced Flip Chip substrate solutions, Fan-Out WLP and Glass interposers...



Both technology & market reports, “5G’s Impact on the RF Front-End Industry” and “Advanced RF System-in-Package for Cell Phones” are detailed on [i-micronews.com](http://i-micronews.com), [RF Devices & Technologies reports section](#).

**ABOUT BOTH REPORTS:**

- [5G's Impact on the RF Front-End Industry](#)

*How will wireless infrastructure and cell phone terminals change in the next decade?* - Produced by Yole Développement (Yole) part of Yole Group of Companies.



Companies cited in the report:

Ampleon, NXP, Sumitomo Electric, M/A-COM, Qorvo, Qualcomm, Broadcom, Wolfspeed, Infineon Technologies, Intel, Murata Manufacturing, Skyworks, Resonant, Akoustis, ACCO Semiconductors, UMS, GlobalFoundries, TOWERJAZZ, TSMC, Win Semiconductors, Samsung, Apple, Huawei, Amkor, ASE Group, IQE... [Full list](#)

- [Advanced RF System-in-Package for Cell Phones 2017](#)

*The transition from 4 G to 5G requires disruptive packaging innovation. 5G mmWave, 5G sub 6 GHz – which packaging architectures can rise to the occasion?* - Produced by Yole Développement (Yole) part of Yole Group of Companies.



Companies cited in the report:

Amkor (J-Devices, Nanium), Apple, ASE Group, Broadcom Ltd. (Avago Technologies, Javelin Semiconductor), Cavendish Kinetics, Cisco, Deca Technologies, Ericsson, Fujitsu, GLOBALFOUNDRIES, Google, Huawei (Hisilicon), Infineon, Intel, JCET/STATS ChipPAC, Kyocera, Lenovo, LG, Marvell, Mediatek ... [Full list](#)

**AUTHORS:**

- **Andrej Ivankovic** is a Technology & Market Analyst, in the Advanced Packaging and Semiconductor Manufacturing team, at Yole Développement the "More than Moore" market research and strategy consulting company. He holds a master's degree in Electrical Engineering, with specialization in Industrial Electronics from the University of Zagreb, Croatia and a PhD in Mechanical Engineering from KU Leuven, Belgium. He started as an intern at ON Semiconductor performing reliability tests, failure analysis and characterization of power electronics and packages. The following 4 years he worked as a R&D engineer at IMEC Belgium on the development of 3D IC technology, focusing on electrical and thermo-mechanical issues of 3D stacking and packaging. Part of this time he also worked at GLOBALFOUNDRIES as an external researcher. He has regularly presented at international conferences authoring and co-authoring 18 papers and 1 patent.
- **Claire Troadec** is leading the RF activity at Yole Développement. She has been a member of the MEMS manufacturing team from 2013. She graduated from INSA Rennes in France with an engineering degree in microelectronics and material sciences. She then joined NXP Semiconductors, and worked for 7 years as a CMOS process integration engineer at the IMEC R&D facility. During this time, she oversaw the isolation and performance boost of CMOS technology node devices from 90 nm down to 45 nm. She has authored or co-authored seven US patents and nine international publications in the semiconductor field and before joining Yole Développement managed her own distribution company.
- **Zhen Zong** works as an analyst for Power Electronics and Compound Semiconductors technologies and market at Yole Développement, the "More than Moore" strategy consulting and market research company. He graduated from INSA Lyon with an engineering degree in material sciences, specialized in semiconductor devices and Micro/Nano technologies.

**About Yole Développement – [www.yole.fr](http://www.yole.fr)**

Founded in 1998, Yole Développement 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 covering MEMS and image sensors, Compound

Semiconductors, RF Electronics, Solid-state lighting, Displays, software, Optoelectronics, Microfluidics & Medical, Advanced Packaging, Manufacturing, Nanomaterials, Power Electronics and Batteries & Energy Management. The “More than Moore” market research, technology and strategy consulting company Yole Développement, along with its partners System Plus Consulting, PISEO and KnowMade, support industrial companies, investors and R&D organizations worldwide to help them understand markets and follow technology trends to grow their business.

- Consulting & Financial Services: Jean-Christophe Eloy ([eloy@yole.fr](mailto:eloy@yole.fr))
- Reports: David Jourdan ([jourdan@yole.fr](mailto:jourdan@yole.fr))

**Yole Group of Companies - Press Relations & Corporate Communication: Sandrine Leroy ([leroy@yole.fr](mailto:leroy@yole.fr))**

###