Active and Passive Antenna Systems for Telecom Infrastructure 2019

Market and Technology Report 2019
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Antoine BONNABEL

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Cédric MALAQUIN

As a Technology & Market Analyst specializing in RF devices & technologies 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 to working with Yole, Cédric was employed at Soitec as a Process Integration Engineer for nine years, and then as an Electrical Characterization Engineer for six years. Cédric has contributed heavily to FDSOI and RF SOI product characterization and has authored or co-authored three patents and five international publications in the semiconductor field. Cédric graduated from Polytech Lille in France with an Engineering degree in Microelectronics and Material Sciences.

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This report covers the global RF infrastructure components market for 4G/5G.

**SCOPE OF THE REPORT**

- RF front-end detailed components: **Included**
- RF architecture and RF line characterization: **Included**
- Frequency and power split: **Included**
- Antenna technologies: **Included**
- Macro-sites, outdoor small cells and backhaul for 4G/5G systems market dynamics, Cloud-RAN, 5G end markets and 5G technologies: **Not included**

*This is addressed in our report: “5G Impact on Telecom Infrastructure 2019”*
REPORT OBJECTIVES

To provide general market dynamics at antenna system level down to component level for 4G/5G telecom infrastructure.

To provide a clear view of the RF front-end architecture in all different telecom infrastructure systems.

To provide RF components technology platforms breakdown.

To provide market forecasts down to component, technology platform and wafer levels for telecom infrastructure RF front-end.

To provide relevant information regarding the complex RF component value chain.
LDMOS will remain the prevailing platform for RF components in telecom infrastructure, but compound semiconductor will see a strong growth.

INFRASTRUCTURE RF FRONT END MARKET FORECAST

By technology platform

- TAM RF front end
  - LDMOS
  - GaAs pHEMT
  - GaN HEMT
  - InGaP HBT
  - SiGe BICMOS
  - PIN diode
  - RF-SOI
  - RF-SOS

2018
$1,477M

2025
$2,525M

CAGR 2018-2025: +8%

RF-CMOS remains < $1M

$791M CAGR +0%

$557M CAGR 8%

$522M CAGR +12%

$360M CAGR 46%

$164M CAGR +68%

$10M CAGR +3%

$96M CAGR +0%

$26M CAGR +40%
Cellular networks get their name from the arrangement of the covered zones into cells. **Cells can be any shape or any size**, but depending on the geographical topology of the cell, the base station will emit more or less power. One trend is at densifying the network using small cells, while upgrading already existing macro-sites. Different cell types with structures emitting at different power levels are used in a cellular network.
RF front-ends for passive antennas include a few high power RF chains.

RF front-ends for active antennas include a multitude of low power RF chains.

The switch from passive to active antennas will result in drastic changes in RF front-ends.

Passive and active antenna system difference. 
Source: Techplayon
The TX stream coming from the transceiver is amplified first with a gain block to reach the RF board, then a three stages amplification (pre-driver, driver and final stage) is performed before reaching the antenna.

A feedback loop on the TX signal is used for the DPD.

The TX signal is sent to the ground by the SPDT switch during the transmission period. The RX signal is sent to the receive path during the receive period.

The RX stream is amplified with an LNA after the antenna. It is then amplified again with a gain block in order to reach the transceiver.
In this particular case, a double-PA module is used in Doherty mode for main amplification, and two separate drivers are used, one per PA stage.
The MTP02P-41A unit is the small cell sold by Samsung to Sprint in the US for B41 access (2.6 GHz).

In total, this system includes:
- 4 DPD and processing units (1 per stream)
- 16 transceivers (4 per stream)
- 64 RF chains / antennas (4 per transceiver)

Transceivers (4 transceivers per streams, 4 antennas per transceiver).
### RF COMPONENT TECHNOLOGY PLATFORM FOR INFRASTRUCTURE

#### Per type of component

<table>
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<th>Driver</th>
<th>Final stage</th>
<th>PA</th>
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<td>SiGe BiCMOS</td>
<td>LDMOS</td>
<td>Final stage</td>
<td>GaN HEMT</td>
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<tr>
<td>InGaP HBT</td>
<td>(Pre) Driver</td>
<td>LDMOS</td>
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<tr>
<td>pHEMT GaAs</td>
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#### Beamformer module

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<th>Low Noise Amplifier</th>
<th>PIN diode</th>
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<td>SiGe BiCMOS</td>
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<tr>
<td>GaN HEMT</td>
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<tr>
<td>RF SOI RF SoS RF CMOS</td>
<td></td>
<td></td>
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<tr>
<td>pHEMT GaAs</td>
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### Active and Passive Antenna Systems for Telecom Infrastructure 2019 | Sample | www.yole.fr | ©2019
Ranking of main player for infrastructure

Based on internal information

Based on annual report information

* NXP revenue includes RF and Digital activities for BTS, while Analog Devices revenue includes RF for BTS/Backhaul, Satcom and Optical activities. Thus, we estimate NXP ranks 1st for RF dedicated to the base station market.
FORECAST EXAMPLES

Antenna systems market forecast per type of technology

- 5G Small Cell
- 5G AAS
- 5G RRH
- 4G AAS
- 4G RRH

CAGR 2019-2025
FORECAST EXAMPLES

Overall infrastructure RF Front End market forecast by component

- Backhaul
- mmWave Beamformer
- AAS <6GHz Beamformer
- Switch
- LNA
- Gain block
- (Pre) Driver
- Final stage PA

CAGR 2018-2025

2018  2019  2020  2021  2022  2023  2024  2025

-1,000 $  0 $  1,000 $  2,000 $  3,000 $
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5G’s Impact on Telecom Infrastructure 2019

Advanced RF System-in-Package for Cellphones 2019

RF GaN Market: Applications, Players, Technology and Substrates 2019

5G’s Impact on RF Front-End Module and Connectivity for Cell phones 2019
ACTIVE AND PASSIVE ANTENNA SYSTEMS FOR TELECOM INFRASTRUCTURE 2019
Market & Technology Report - November 2019

The transition to active antenna systems and small cells is changing the technological mix of RF components in telecom infrastructure.

A DRAGSTIC TECHNOLOGY CHANGE FUELED BY A VALUE DIVERSION

5G has brought huge changes in the telecom infrastructure industry, with the use of higher frequencies and with the arrival of active antenna systems (AAS). These systems use up to 64 independent radio frequency (RF) chains that can create direct beams, addressing specific users instead of radiating over a large area. From a practical standpoint, using such beamforming results in using 64 sets of RF components instead of two with standard remote radio head (RRH) based technologies. These components generate lower power output at antenna level, and the industry has had to adapt its technology to emitting at lower power levels. In addition to that, the newly released frequencies for 5G use are higher in frequency than current technologies. Asking for devices able to work at frequencies up to 3.5GHz today, and up to 6GHz in the future, obviously impacts the RF component industry.

From a cost standpoint, adding new components and multiplying RF chains has increased the RF front-end bill of materials for antenna systems. This is a critical change as the telecom infrastructure market is static. Instead of growing, this market is defined by the telecom operators’ investment levels, which have stayed stable all over the world in the past decades. At system and component level, this situation induces a focus on margin improvement and securing market share in order to increase profitability. The arrival of 5G will not change this trend unless new markets such as enterprise or industrial applications open up to operators, but this is not anticipated in the short term.

In order to implement these new antenna systems, some methods of cost reduction and optimization have appeared, such as antenna sharing between operators, or the development of Cloud-Radio Access Networks (RAN) that are supposed to offer higher information management optimization. This saved value is then diverted toward the RF front-end and the new antenna systems, namely the AAS.

NEW TECHNOLOGY PLATFORMS TO CHALLENGE STANDARD ONES

The RF front-end market for telecom infrastructure is estimated to be worth $1.47B in 2018 and is forecasted to reach $2.52B in 2025. In this market, the main technology platform is LDMOS. This will remain the case for the next several years, but LDMOS is not expected to see any significant growth despite an increase in component volumes shipped. It will see an almost null compound annual growth rate (CAGR) in a market growing by 8% on average between 2018 and 2025. On the other hand, other platforms such as GaN, GaAs, SiGe or RF-silicon-on-insulator (SOI) will see significant growth in the near future.
One of the most interesting dynamics in this matter is the expected evolution of the GaAs platform. With the arrival of AAS, a higher number of low power broadband power amplifiers will be needed, as well as new components such as beamformers. These components are expected to be made mostly on the GaAs platform at first, especially for performance reasons. It provides the right performance level in a market for which no failure is allowed. But once the market has grown enough to be considered larger than a niche, other technologies like RF-SOI or SiGe are expected to replace GaAs, the same way GaAs has been replaced in the mobile phone industry. GaAs will be a transition platform for active antenna components.

**ACTIVE AND PASSIVE ANTENNA SYSTEMS FOR TELECOM INFRASTRUCTURE 2019**

MULTIPLE PLAYERS, BUT CONSOLIDATION AWAITS TELECOM OPERATORS’ TECHNOLOGY CHOICES

Unlike the mobile phone industry, RF front end component manufacturers in the telecom infrastructure industry are numerous and specialized. A lot of different technological platforms are used, leading to a wide variety of components being available. In this fragmented industry, very few acquisitions have been seen lately and there has been little investment in start-ups. This is due to the fact that the industry is still unsure about the choices telecom operators will make in terms of deployment. A noticeable example has been China Mobile (CMCC), which has changed technological orientation twice over the past few years. It was first interested in 64 antenna

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**Main players ranking for communication infrastructure revenue (in $M)**

- **PSEMI**
- **RFHIC**
- **ST Microelectronics**
- **Mitsubishi Electric**
- **Skyworks**
- **M/A-COM**
- **SEDI**
- **Ampleon**
- **Wolfspeed**
- **Qorvo**
- **Analog Devices**
- **NXP**

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* NXP revenue includes RF and Digital activities for BTS, while Analog Devices revenue includes RF for BTS/Backhaul, Satcom and Optical activities. Thus, Yole Développement estimates NXP ranks 1st for RF dedicated to the base station market.
element AAS, thus motivating the industry to develop components with RF power amplifiers in the 5W range. But then CMCC went back to a preference for 32-element systems for cost reasons, rendering the developed elements unsuitable. Now CMCC has again started to go back on its plans of large scale implementation of AAS in favor of a more standard, lower cost RRH-based deployment. CMCC also decided to not go to frequencies above 3GHz in the near future, thus completely changing the perspective for GaN device developers like Sumitomo. All these strategic changes impact technology development and create huge uncertainties in the industry. This market will first need to know which direction will be chosen by telecom operators before being able to consolidate.

REPORT OBJECTIVES

• Provide general market dynamics at antenna system level down to component level for 4G/5G telecom infrastructure
• Provide a clear view of the RF front-end architecture in all different telecom infrastructure systems
• Provide RF component technology platform breakdowns
• Provide market forecasts down to component, technology platform and wafer levels for telecom infrastructure RF front-ends
• Provide relevant information regarding the complex RF component value chain

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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. He has also authored or co-authored three patents and five international publications in the semiconductor field. Cédric graduated from Polytech Lille in France with an engineering degree in microelectronics and material sciences.
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- An understanding of your manufacturing and production costs
- An understanding of your industry’s technology roadmap and related IPs
- A clear view supply chain evolution

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In 2019 we will extend our offering with a new ‘monitor’ product which provides more updates on your industry during the year. The Yole Group of Companies is also building on and expanding its investigations of the memory industry. Moreover, in parallel, the Yole Group reaffirms its commitment to a new collection of reports mixing software and hardware and is increasing its involvement in displays, radio-frequency (RF) technology, advanced substrates, batteries and compound semiconductors. Last but not least, System Plus Consulting is developing its teardowns service providing 120+ offers related to phones, smart home, wearables and connected devices. Discover our 2019 program right now, and ensure you get a true vision of the industry. Stay tuned!
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More than describing the status of the IP situation, these analyses provide a missing link between patented technologies and market, technological and business trends. They offer an understanding of the competitive landscape and technology developments from a patent perspective. They include key insights into key IP players, key patents and future technology trends. For 2019 KnowMade will release over 15 reports.

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Linked reports are dealing with the same topic to provide a more detailed analysis.
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**IMAGING**
- **MARKET AND TECHNOLOGY REPORT**
  - Status of the CIS Industry 2019: Technology and Foundry Business - Update
  - Imaging for Automotive 2019 - Update
  - Neuromorphic Sensing and Computing 2019 - Update
  - Status of the Camera Module Industry 2019 - Focus on Wafer Level Optics – Update
  - 3D Imaging & Sensing 2018
  - Machine Vision for Industry and Automation 2018

**STRUCTURE, PROCESS & COST REPORT**
- Compact Camera Modules Comparison 2019
- CMOS Image Sensors Comparison 2019

**PATENT REPORT**
- Facial & Gesture Recognition Technologies in Mobile Devices 2019 - New
- Apple iPhone X Proximity Sensor & Flood Illuminator 2018

**MEDICAL IMAGING AND BIOPHOTONICS**
- **MARKET AND TECHNOLOGY REPORT**
  - X-Ray Detectors for Medical, Industrial and Security Applications 2019 - New
  - Microscopy Life Science Cameras: Market and Technology Analysis 2019
  - Ultrasound technologies for Medical, Industrial and Consumer Applications 2018

**STRUCTURE, PROCESS & COST REPORT**
- Piezoelectric Materials from Bulk to Thin Film Comparison 2019

**INKJET AND ACCURATE DISPENSING**
- **MARKET AND TECHNOLOGY REPORT**
  - Inkjet Printheads - Dispensing Technologies & Market Landscape 2019 - Update
  - Emerging Printing Technologies for Microsystem Manufacturing 2019 - New
  - Piezoelectric Devices from Bulk to Thin Film 2019 - New
  - Inkjet Functional and Additive Manufacturing for Electronics 2018

**PATENT REPORT**
- Optical Coherence Tomography Medical Imaging 2018

**MICROFLUIDICS**
- **MARKET AND TECHNOLOGY REPORT**
  - Status of the Microfluidics Industry 2019 - Update
  - Organs-on-chips Market and Technology Landscape 2019 - Update
  - Point-of-Need Testing Application of Microfluidic Technologies 2018
  - Liquid Biopsy: from Isolation to Downstream Applications 2018
  - Chinese Microfluidics Industry 2018

**STRUCTURE, PROCESS & COST REPORT**
- Piezoelectric Manufacturing Technologies 2019 – New
- Nanopore Sequencing 2019 - New

Update : 2018 version still available

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OUR 2019 REPORTS COLLECTION (3/5)

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**BIOMEMS & MEDICAL MICROSYSTEMS**
- **MARKET AND TECHNOLOGY REPORT**
  - Medical Wearables: Market & Technology Analysis 2019 - New
  - Neurotechnologies and Brain Computer Interface 2018
  - BioMEMS & Non-Invasive Sensors: Microsystems for Life Sciences & Healthcare 2018
- **PATENT REPORT**
  - 3D Cell Printing 2019 - New
  - Circulating Tumor Cells Isolation 2019 - New

**SOFTWARE AND COMPUTING**
- **MARKET AND TECHNOLOGY REPORT**
  - Artificial Intelligence Computing For Automotive 2019 - New
  - Artificial Intelligence Computing for Consumer 2019 - Update
  - Image Signal Processor and Vision Processor Market and Technology Trends 2019
  - xPU (Processing Units) for Cryptocurrency, Blockchain, HPC and Gaming 2019 – New
  - Artificial Intelligence for Medical Imaging 2019 - New
- **PATENT REPORT**
  - Artificial Intelligence for Medical Diagnostics - New

**MEMORY**
- **MARKET AND TECHNOLOGY REPORT**
  - Status of the Memory Industry 2019 - New
  - MRAM Technology and Business 2019 - New
  - Emerging Non Volatile Memory 2018
- **STRUCTURE, PROCESS & COST REPORT**
  - Memory Comparison 2019
- **PATENT REPORT**
  - Magnetoresistive Random-Access Memory (MRAM) 2019 - New
  - 3D Non-Volatile Memory 2018

**ADVANCED PACKAGING**
- **MARKET AND TECHNOLOGY REPORT**
  - Fan Out Packaging Technologies and Market Trends 2019 - Update
  - 2.5D/3D TSV & Wafer-Level Stacking:Technology & Market Updates 2019- Update
  - Advanced RF SiP for Cellphones 2019 - Update
  - Status of the Advanced Packaging Industry 2019 - Update
  - Status of the Advanced Substrates 2019 - Update
  - Automotive Packaging Market & Technology Trends 2019 - New
  - Trends in Automotive Packaging 2018
  - Thin-Film Integrated Passive Devices 2018
  - Die Attach Equipment Trends 2019 en Semiconductor Manufacturing - New
- **STRUCTURE, PROCESS & COST REPORT**
  - Advanced RF SiP for Cellphones Comparison 2019

Update: 2018 version still available
OUR 2019 REPORTS COLLECTION (4/5)

18 fields of excellence combined with six markets to provide a complete picture of your industry landscape

SEMICONDUCTOR MANUFACTURING

MARKET AND TECHNOLOGY REPORT
- Nano-Imprint Technology Trends for Semiconductor Applications 2019 - New 🔗
- Equipment and Materials for Fan Out Packaging 2019 - Update 🔗
- Equipment for More than Moore: Thin Film Deposition & Etching 2019 - New 🔗
- Wafer Starts for More Than Moore Applications 2018 🔗
- Polymeric Materials at Wafer-Level for Advanced Packaging 2018 🔗
- Bonding and Lithography Equipment Market for More than Moore Devices 2018 🔗

STRUCTURE, PROCESS & COST REPORT
- Wafer Bonding Comparison 2018 🔗
- Hybrid Bonding for 3D Stack 2019 – New 🔗

SOLID STATE LIGHTING

MARKET AND TECHNOLOGY REPORT
- Status of the Solid-State Lighting Source Industry 2019- New 🔗
- Edge Emitting Lasers (EELS) 2019 - New 🔗
- Light Shaping Technologies 2019 – New 🔗
- Automotive Advanced Front Lighting Systems 2019 - New 🔗

DISPLAY

MARKET AND TECHNOLOGY REPORT
- Next Generation 3D Displays 2019 - New 🔗
- Next Generation Human Machine Interaction (HMI) in Displays 2019 - New 🔗
- MicroLED Displays 2019 - Update 🔗
- MiniLED 2019 - Update 🔗
- Displays & Optical Vision Systems for VR, AR & MR 2018 🔗

PATENT REPORT
- MicroLED Displays : Intellectual Property Landscape 2018 🔗

VCSELs – Market and Technology Trends 2019 - Update 🔗
- IR LEDs and Laser Diodes – Technology, Applications, and Industry Trends 2018 🔗
- UV LEDs - Technology, Manufacturing and Application Trends 2018 🔗
- LiFi: Technology, Industry and Market Trends 2018 🔗

STRUCTURE, PROCESS & COST REPORT
- VCSEL Comparison 2019 🔗
- VCSELs 2018 🔗

Update : 2018 version still available

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POWER ELECTRONICS
- MARKET AND TECHNOLOGY REPORT
  - Power SiC: Materials, Devices and Applications 2019 - Update
  - Power Electronics for EV/HEV and e-mobility: Market, Innovations and Trends 2019 - Update
  - Status of the Power Electronics Industry 2019 - Update
  - Discrete Power Packaging: Material Market and Technology Trends 2019 - New
  - Status of the Power ICs Industry 2019 - Update
  - Status of the Inverter Industry 2019 - Update
  - Status of the Power Module Packaging Industry 2019 - Update
  - Wireless Charging Market Expectations and Technology Trends 2018
  - Power GaN 2018: Epitaxy, Devices, Applications and Technology Trends

- STRUCTURE, PROCESS & COST REPORT
  - Automotive Power Module Packaging Comparison 2018
  - GaN-on-Silicon Transistor Comparison 2019
  - SiC Transistor Comparison 2019

- PATENT REPORT
  - Power SiC: Materials, Devices and Modules 2019 - New
  - Power GaN: Materials, Devices and Modules 2019 – Update

BATTERY & ENERGY MANAGEMENT
- MARKET AND TECHNOLOGY REPORT
  - Status of the Rechargeable Li-ion Battery Industry 2019 - New
  - Patent Report
  - Battery Energy Density Increase: Materials and Emerging Technologies 2019 - New
  - Solid-State Batteries 2019 - New
  - Status of the Battery Patents 2018

- COMPOUND SEMI.
  - MARKET AND TECHNOLOGY REPORT
    - Emerging Semiconductor Substrates: Market & Technology Trends 2019 - New
    - InP Wafer and Epiwafer Market - Photonic and RF Applications 2019 - New
    - GaAs Wafer and Epiwafer Market: RF, Photonics, LED and PV Applications 2018

- PATENT REPORT
  - GaN-on-Silicon Substrate: Materials, Devices and Applications 2019 - Update

BIOTECHNOLOGIES
- MARKET AND TECHNOLOGY REPORT
  - CRISPR-Cas9 Technology: From Lab to Industries 2018

- PATENT REPORT
  - Personalized Medicine 2019 – New
OUR 2019 MONITORS COLLECTION (1/2)

Get the most updated overview of your market to monitor your strategy

Yole Développement, System Plus Consulting and KnowMade, all part of the Yole Group of Companies, are launching a collection of 10 monitors in 2019. The monitors aim to provide updated market, technology and patent data as well dedicated quarterly analyses of the evolution in your industry over the previous 12 months. Furthermore, you can benefit from direct access to the analyst for an on-demand Q&A and discussion session regarding trend analyses, forecasts and breaking news.

Topics covered will be compact camera modules (CCMs), advanced packaging, compound semiconductors, microfluidics, batteries, RF and memory.

MARKET MONITOR by Yole Développement

A FULL PACKAGE:
The monitors will provide the evolution of the market in units, wafer area and revenues. They will also offer insights into what is driving the business and a close look at what is happening will also be covered in it.

The following deliverables will be included in the monitors:

- An Excel database with all historical and forecast data
- A PDF slide deck with graphs and comments/analyses covering the expected evolutions

- ADVANCED PACKAGING – NEW
This monitor will provide the evolution of the advanced packaging platforms. It will cover Fan-Out Wafer Level Packaging (WLP), Fan-Out Panel Level Packaging (PLP), Wafer-Level Chip Scale Packaging (WLCSP), Flip Chip packaging platforms, and 2.5D and 3D Through Silicon Via (TSV) integration. Frequency: Quarterly, starting from Q4 2019

- COMPOUND SEMI. – NEW
This monitor will describe how the compound semiconductor industry is evolving. It will offer a close look at GaAs, InP, SiC, GaN and other compounds of interest providing wafer volumes, revenues, application breakdowns and momentum. Frequency: Quarterly, starting from Q 2019

- CMOS IMAGE SENSORS – NEW
This monitor will provide the evolution of the imaging industry, with a close look at image sensor, camera module, lens and VCM. Volumes, revenues and momentum of companies like Sony, Samsung, Omnivision and OnSemi will thus be analysed. Frequency: Quarterly, starting from Q3 2019

- MEMORY – UPDATE
For the memory industry you can have access to a quarterly monitor, as well as an additional service, a monthly pricing. Both services can be bought separately:
  - DRAM Service: Including a quarterly monitor and monthly pricing.
  - NAND Service: Including a quarterly monitor and monthly pricing.

REVERSE TECHNOLOGY MONITOR by System Plus Consulting

- SMARTPHONES – NEW
To stay updated on the latest components, packaging and silicon chip choices of the smartphone makers, System Plus Consulting has created its first Smartphone Reverse Technology monitor. This year, get access to the packaging and silicon content database of at least 20 different flagship smartphones – more than five per quarter. Starting at the beginning of 2020, the monitor will include an Excel database report for each phone and a quarterly comparison.
OUR 2019 MONITORS COLLECTION (2/2)

Get the most updated overview of your market to monitor your strategy

PATENT MONITOR by KnowMade

A FULL PACKAGE:
Starting at the beginning of the year, the KnowMade monitors include the following deliverables:

- An Excel file including the monthly IP database of:
  - New patent applications
  - Newly granted patents
  - Expired or abandoned patents
  - Transfer of IP rights through re-assignment and licensing
  - Patent litigation and opposition
- Quarterly report including a PDF slide deck with the key facts & figures of the quarter: IP trends over the three last months, with a close look to key IP players and key patented technologies.

- GaN for Power & RF Electronics
  Wafers and epifaces, GaN-on-SiC, silicon, sapphire or diamond, semiconductor devices such as transistor, and diodes, devices and applications including converters, rectifiers, switches, amplifiers, filters, and Monolithic Microwave Integrated Circuits (MMICs), packaging, modules and systems.

- GaN for Optoelectronics & Photonics
  Wafers and epifaces, GaN-on-sapphire, SiC or silicon; semiconductor devices such as LEDs and lasers; and applications including lighting, display, visible communication, photonics, packaging, modules and systems.

- Li-ion Batteries
  Anodes made of lithium metal, silicon, and lithium titanate (LTO); cathodes made of Lithium Iron Phosphate (LFP); Nickel-Manganese-Cobalt (NMC), Lithium Nickel Cobalt Aluminium Oxide (NCA), Lithium Nickel Metal Dioxide (LiNiM02), Lithium Metal Phosphate (LiMPO4), and Lithium Metal Tetroxide (LiMO4); electrolytes including liquid, polymer/gel, and solid inorganics; ceramic and other separators; battery cells including thin film/microbattery, flexible, cylindrical and prismatic; and battery packs and systems.

- Post Li-ion Batteries
  Battery technologies including redox-flow batteries, sodium-ion, lithiumsulfur, lithium-air, and magnesium-ion, and their supply chains, including electrodes, electrolytes, battery cells and battery packs/systems.

- Solid-State Batteries
  Supply chain including electrodes, battery cells, battery packs/systems and electrolytes, including polymer, inorganic and inorganic/polymer, inorganic materials, including argyrodites, Lithium Super Ionic CONductor, (LISICONs), Thio-LISICONs, sulfide glasses, oxide glasses, perovskites, anti-perovskites and garnets.

- RF Acoustic Wave Filters
  Including Surface Acoustic Wave (SAW), Temperature Compensated (TC)- SAW, Bulk Acoustic Wave- Free-standing Bulk Acoustic Resonator (BAWFBAR), BAW-Solidly-Mounted Resonator (BAW-SMR), and Packaging.

- RF Power Amplifiers
  Including Low Noise Amplifiers, Doherty Amplifiers, Packaging, and Millimeter-Wave technology.

- RF Front-End Modules

- Microfluidics
  From components to chips and systems, including all applications.
To meet the growing demand for market, technological and business information, i-Micronews Media integrates several tools able to reach each individual contact within its network.

We will ensure your company benefits from this

### ONLINE

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i-Micronews.com
FreeFullPDF.com

**Unique, cost-effective ways to reach global audiences.**
Online display advertising campaigns are great strategies for improving your product/brand visibility. They are also an efficient way to adapt with the demands of the times and to evolve an effective marketing plan and strategy.

- **#15,800+ monthly unique visitors on i-Micronews.com**
- **#10,900+ weekly readers of i-Micronews e-newsletter**

### ONSITE

Events

**Brand visibility, networking opportunities**
Today’s technology makes it easy for us to communicate regularly, quickly, and inexpensively – but when understanding each other is critical, there is no substitute for meeting in-person. Events are the best way to exchange ideas with your customers, partners, prospects while increasing your brand/product visibility.

- **#110 attendees on average**
- **#7+ key events planned for 2019 on different topics**

### INPERSON

Webcasts

**Targeted audience involvement equals clear, concise perception of your company’s message.**
Webcasts are a smart, innovative way of communicating to a wider targeted audience. Webcasts create very useful, dynamic reference material for attendees and also for absentees, thanks to the recording technology.

- **#380 registrants per webcast on average to gain new leads for your business**

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