Status of the Advanced Packaging Industry 2019

Market and Technology Report 2019
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Santosh Kumar is currently working as Principal Analyst and Director Packaging, Assembly & Substrates, Yole Korea. Based in Seoul, Santosh is involved in the market, technology and strategic analysis 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 and master degree in engineering from the Indian Institute of Technology (IIT), Roorkee and University of Seoul respectively. He has published more than 40 papers in peer reviewed journals and has obtained 2 patents. He has presented and given talks at numerous conferences and technical symposiums related to advanced microelectronics packaging.

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As a Technology & Market Analyst, Advanced Packaging, Mario Ibrahim is a member of the Semiconductor & Software division at Yole Développement (Yole). Mario is engaged in the development of technology & market reports as well as the production of custom consulting studies. He is also deeply involved in test activities business development within the division. Prior to Yole, Mario was engaged in test activities development on LEDs at Aledia. He was also in charge of several R&D advanced packaging programs. During his 5 years stay, he developed strong technical & managerial expertise in different semiconductor fields. Mario holds an Electronics Engineering Degree from Polytechn’ Grenoble (France). He spent 3 apprenticeship years within Imaging Division of STMicroelectronics Grenoble, where he contributed to the test benches park automation within the test & validation team.

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Favier Shoo is a Technology and Market Analyst in the Semiconductor & Software division at Yole Développement (Yole), part of Yole Group of Companies. Based in Singapore, he is engaged in the development of reports as well as the production of custom consulting projects. With prior experiences at Applied Materials and REC Solar, Favier had developed a deep understanding of the supply chain and core business values. Being knowledgeable in this field, Favier had conducted professional trainings for industry players and obtained 2 patents. He was also the co-founder of a startup company. Favier holds a Bachelor in Materials Engineering (Hons) and a Minor in Entrepreneurship from Nanyang Technological University (NTU) (Singapore).

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COMPANIES CITED IN THIS REPORT

> 100 companies cited in the report


(non-exhaustive list)
METHODOLOGIES & DEFINITIONS

Yole’s market forecast model is based on the matching of several sources:

Comparison with existing data
Monitoring of corporate communication
Using other market research data
Yole analysis (consensus or not)

Comparison with prior Yole reports
Recursive improvement of dataset
Customer feedback

Preexisting information

Top-to-bottom approach
Aggregate of market forecasts
@ System level

Top-to-bottom approach
Aggregate of market forecast
@ Semiconductor device level

Market
Volume (in Munits)
ASP (in $)
Revenue (in $M)

Bottom-up approach
Ecosystem analysis
Aggregate of all players’ revenue
@ System level

Bottom-up approach
Ecosystem analysis
Aggregate of key players’ revenues
@ Semiconductor device level

Primary data
• Reverse costing
• Patent analysis
• Annual reports
• Direct interviews

Secondary data
• Press releases
• Industry organization reports
• Conferences

Information Aggregation

Semiconductor foundry activity
Capacity investments and equipment needs

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WHAT’S NEW IN THE STATUS OF ADVANCED PACKAGING 2019?

- Updated forecast of the semiconductor market including memory & non-memory components
- Update of Advanced Packaging market data (2018-2024):
  - By revenue, wafer, and unit forecasts
  - By advanced packaging platforms: flip-chip, fan-out, fan-in, 2.5D/3D IC, embedded die
- Analysis of US-China effect on semiconductor business & supply chain
- Included 2018 - 2024 revenue, wafer, and unit forecasts, by various application segments: consumer & mobile, automotive & transportation, telecom & infrastructure, medical, industrial, defense & aerospace
- Updated supply chain analysis with focus on impact of foundry entry into advanced packaging business
- Wafer starts share by manufacturers from different business model (IDM, OSAT, foundry) by different advanced packaging platform and its evolution
- Updated financial analysis of the top 25 OSATs (2018-2013) by different parameters: Revenue, YoY growth, R&D, Capex, Gross profit, Gross Margin, Net Income etc.
- M&As data update and different scenarios for OSATs for 2019-2024
KEY FEATURES OF THIS REPORT

The “Status of the Advanced Packaging Industry” is a yearly overview report. The objectives of the report are as follows:

• Advanced packaging market overview
  • Drivers and dynamics
  • Future applications
  • Disruptions and opportunities

• Technology trends and forecasts
  • Revenue, wafer and unit forecasts by platform
  • Future development by platform
  • Impact of front-end scaling
  • Scaling and functional roadmaps

• Supply chain analysis
  • Overview of production by player (IDM, OSAT, foundry)
  • Shifting business models
  • Financial analysis of TOP 25 OSATs
WHAT’S NEW FROM THE ADVANCED PACKAGING TEAM?

Advanced Substrates and RF packaging activities

In 2017, the Advanced Packaging team at Yole Développement established “Advanced Substrates” and “RF Packaging” as standalone and separate activities, to allow deeper focus on these segments.

The “Advanced Substrate” activity is dedicated to exploring the market and technologies of PCBs, IC substrates and thin film RDLs.

The “RF Packaging” activity deals with low power RF packaging as requirement for the rise of high frequency packaging (5G).

The objectives of these activities will be to:

- Propose a common terminology framework
- Identify and analyze competitive and overlapping technologies
- Analyze the supply chain and business model shifts
- Provide related market forecasts
- Provide related technology roadmaps
- Provide an outlook on market dynamics and disruptions
- Identify market shares of involved players
- Provide analysis on substrate and RF packaging - architectures, equipment and materials
SYSTEM INTEGRATION LEVELS

LEVEL 3: End Device/Equipment

LEVEL 2: Device/Equipment Board

LEVEL 1: Semiconductor Packaging

LEVEL 0: Semiconductor Die/Wafer

iPhone 6

iPhone 6 PCB

Qorvo RF SiP in the iPhone 6s Plus

Power amplifier in Qorvo RF SIP

LEVEL 1+2: Semiconductor Package + Board

Semiconductor package

Si dies

Package Substrate

Board (PCB)
BOARD VS. SUBSTRATE VS. THIN FILM RDL

Multi-Die FC BGA

Substrate

Multi-Die Fan-Out WLP/PLP

Thin Film RDL

Interposer

2.5D/3D IC on FC BGA

Fan-In WLP
DIGITAL SOCIETY: NEW TRENDS & MARKET DRIVERS

Disruptive Technology

- Motion sensing
- Olfactometry
- Imaging
- Audio

TRENDS

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<th>PC</th>
<th>Mobile</th>
<th>Smart</th>
<th>Robotics</th>
<th>Human Augmentation</th>
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<td>3D graphics cards</td>
<td>Deep neural network</td>
<td>Deep neural network with GPU</td>
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3 BIG TRENDS DRIVING SEMICONDUCTOR BUSINESS

5G, AI & IoT are 3 key trends driving the next generation semiconductor business, encompassing various applications & devices.
## SIP TECHNOLOGY ROADMAPS

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<th>Typical</th>
<th>Metrics</th>
<th>&lt;2017</th>
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<th>2022</th>
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Roadmap described here based on an expected average of the different technologies in the market.
NEW ADVANCED PACKAGING ARCHITECTURES ANNOUNCED SINCE 2018

- The innovation in the high end advanced packaging is currently led by TSMC. Since 2011 when CoWoS was introduced by TSMC as the high end advanced packaging platform involving Si interposer for heterogeneous integration, there is series of innovation from InFO (& its multiple versions InFO-OS, InFO-AiP) to SoIC to 3D Multi-stack (MUST) system integration technology and 3D MUST-in-MUST (3D-MiM fan out package)

- **System-on-Integrated-Chips (SoIC)**

- Last year TSMC announced the SoIC advanced packaging technology, that is slated to go into mass production in 2021. SoIC is a type of innovative multi-chip stacking technology, which can be used to carry out wafer-bonding in the manufacture of chips which are 10nm and less. SoIC is a “bumpless” interconnect method between multiple die. The SoIC solution enables known good dies of different sizes, process technologies, and materials to be directly stacked together. Compared to typical 3DIC solutions with micro-bumps, TSMC’s SoIC delivers higher bump density and speed, while consuming much less power. What’s more, SoIC is a “front-end” integration solution connecting two or more dies before they are packaged. Therefore, a SoIC stack can be further integrated with other SoIC or chips in one of TSMC’s “back-end” advanced packaging technologies such as InFO or CoWoS, offering a powerful “3D-by-3D” system-level solution.

- TSMC is collaborating on this with EDA tool vendors to introduce design and verification tools for manufacturing technology and are working with a few leading customers on the technology
OSATS PACKAGING BUSINESS CANNIBALIZATION TREND

- Packaging / assembly business was traditionally domain of OSATs & IDMs
- Players from different business models viz. Foundries, Substrate/PCB suppliers, EMS/DM are entering the assembly /packaging business & cannibalizing the OSAT business

3 IDMs (Intel, Samsung, SK Hynix), a foundry (TSMC) and top 5 global OSATs + Nepes and Chipbond process approx. X % of advanced packaging wafers.

NOTE:
- This pie chart represents superpositions of all advanced packaging platforms (Fan-In/Fan-Out WLP, Flip Chip including 2.5D/3D and Embedded die)
- Flip Chip values are entered as total capacity, WLP and Embedded die as total production
- Flip Chip production values were not available per customer – global utilization is at ~85% of capacity
Financial Overview for Top 25 OSATs

Revenue in 2018

- Top OSATs with heavy investments were creating a disparity with the rest of the pack.
- Top 8 OSATs now include 3 manufacturers HQ in China. UTAC maintained at 8th spot.
- Companies in the tail are at a higher risk if there is no differentiated technology or IP for merger and acquisition as an exit strategy.

Players not within the Top 8 ranking need to catch up. Otherwise, they will risk getting acquired or incur loss in business.

- Large OSATs were separated from the rest.
- Top 8 OSATs continued the heavy investment in CapEx and R&D.
• Semiconductor M&A is in decline since 2015 from historic high of ~$125B
• Semiconductor M&A increased dramatically in 2015 and 2016 (soaring to $124.5B and $111B, respectively), though fell in 2017 to $30.5B and increased slightly (3%) in 2018 to $31.3B
• Total semiconductor M&A 2013-2018 accounted for $314B
• Out of total semiconductor M&A, Packaging M&A was only $2.05B in all 4 past years combined
• Of the $2.05B, the majority of M&A was from only 4 deals, the JCET acquisition of STATSChip PAC ($780M), Nantong Fujitsu takeover of AMD plants in China ($371M), Amkor takeover of J-Devices ($105M) and Huatian takeover of Unisem ($451M, proposed)

~$62B of semiconductor M&A in the last 2 years
Assembly / Packaging M&A a small fraction so far ($2.05B, <1% of total).
Advanced packaging revenue as % of total packaging

Year | AP vs Total Packaging (%)
--- | ---
2018 | 42.1%
2019 | 57.9%
2020 |
2021 |
2022 |
2023 |
2024 | 50.3%

Total packaging CAGR 5%
CAGR 2.4%
CAGR 8.2%

~$62B of semiconductor M&A in the last 2 years
Assembly / Packaging M&A a small fraction so far ($2.05B, <1% of total).

Total packaging market grows by 5% whereas AP market grows by 8.2%
The advanced packaging market was ~$27.6B in 2018. It is expected to grow at ~8% CAGR (2018-2024) to reach ~$43.6B in 2024.

- Highest Revenue CAGR expected from 2.5D / 3D TSV, ED (in laminate substrate) and Fan-Out, 26%, 49% and 26%, respectively, as high volume products further penetrate the market.
  - FO in mobile, networking, automotive;
  - 2.5D/3D TSV in AI/ML, HPC, data centers, CIS, MEMS/sensors;
  - ED in automotive and medical

**NOTE:**
- Values represent packaging services (assembly and test) and do not include FEOL Si die processing
- This TSV category includes packaging revenue from high end (3D TSV memory, 2.5D interposer &3D SoC), middle end (CIS) and low end (MEMS/sensors)
- TSV is represented separately in the graph for visualization/comparison purposes as the high end of TSV is represented in FC and some low end TSV is part of Fan-in. So, the different AP numbers don’t add to the total.
## ADVANCED PACKAGING REVENUE FORECAST: BREAKDOWN BY APPLICATIONS

<table>
<thead>
<tr>
<th>Application</th>
<th>2018 Revenue</th>
<th>CAGR (2018-2024) ~ XX%</th>
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<tbody>
<tr>
<td>Mobile &amp; Consumer</td>
<td>$27.6B</td>
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<tr>
<td>Automotive &amp; Transportation</td>
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<td>Telecom &amp; Infrastructure</td>
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<td>Others*</td>
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### Breakdown by Application

- **Mobile & Consumer**: $27.6B
- **Automotive & Transportation**: $3.2B, CAGR (2018-2024) ~ XX%
- **Telecom & Infrastructure**: $1.9B, CAGR (2018-2024) ~ XX%
- **Others***: CAGR (2018-2024) ~ XX%

### Projections

- **2018**: $27.6B
- **2024**: $43.6B

*Others include, medical, infrastructure & aerospace/defense segments*
YOLE GROUP OF COMPANIES RELATED REPORTS

Yole Développement

Fan-Out Packaging: Technologies and Market Trends 2019

2.5D / 3D TSV & Wafer-Level Stacking: Technology & Market Updates 2019

Status of Advanced Substrates 2019

Status of Panel Level Packaging 2018

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Samsung Exynos 9110 with ePLP: First Generation of Samsung’s Fan-Out Panel Level Packaging (FO-PLP)
Despite the semiconductor industry’s slowdown, advanced packaging is growing at an impressive 8% CAGR (2018 - 2024).

The semiconductor industry is at a turning point. The slowdown in CMOS scaling, coupled with escalating costs, has prompted the industry to rely on IC packaging to extend the benefits of the More-than-Moore era. Thus, advanced packaging has entered its most successful period, boosted by widespread needs for better integration; the slowdown of Moore’s law; and megatrends in transportation, 5G, consumer, memory & computing, IoT (and IIoT), AI, and HPC.

After experiencing double-digit growth and achieving record revenue in 2017 and 2018, Yole Développement (Yole) expects a slowdown (negative YoY growth) in the semiconductor industry for 2019. However, advanced packaging is expected to maintain its growth momentum, with ~6% YoY growth. Overall, the advanced packaging market will grow at an 8% CAGR, reaching ~$44B in 2024. Conversely, during the same period the traditional packaging market will grow at 2.4% CAGR, and the total IC packaging business will exhibit a 5% CAGR.

Yole’s report, Status of the Advanced Packaging Industry 2019, explores the field of advanced packaging and represents a comprehensive yearly overview of the latest market and technology developments. The report first summarizes the drivers for advanced packaging and the latest market dynamics, and then examines packaging technology evolution with the help of short- and long-term roadmaps. Also included is an analysis of the trends and challenges related to advanced packaging technology, supported by detailed roadmaps for the various packaging platforms. Furthermore, this report provides a deep analysis of the supply chain, including player positioning and strategy/production per player (revenue, wafers). This supply chain analysis includes a thorough financial inquiry of the top 25 OSATs. The report concludes by providing revenue, wafer, and unit forecasts per packaging platform, along with a review of future production and possible developments during the 2018 - 2024 timeframe.

FLIP-CHIP CURRENTLY CONSTITUTES THE BULK OF THE ADVANCED PACKAGING BUSINESS, BUT 3D IC STACKING AND FAN-OUT ARE THE FASTEST-GROWING ADVANCED PACKAGING PLATFORMS

In 2018, flip-chip constituted ~81% of the advanced packaging market. However, by 2024 its share will decrease to ~72%. Of the different advanced packaging platforms, 3D IC stacking and fan-out will each grow at a rate of ~26%, and their adoption will continue increasing across various applications. No other technology can provide the performance and integration level reached by actual stacking technologies based on TSV, hybrid bonding, or a combination of both. The high-end TSV market’s growth is led by 3D memory (HBM and 3D DDR DRAM), 2.5D interposer-based die
partitioning, and logic-memory integration. The HBM business is enjoying high growth, led by AI/ML, HPC, and data centres. Fan-out packaging is being utilized in more applications (BB, PMIC, RF, APE, memory) while simultaneously penetrating new markets. In fact, the fan-out packaging market is expected to show strong growth, with players from different business models all entering the market. Led mostly by mobile, fan-in WLP will grow at a 6.5% CAGR over 2018 - 2024. Embedded die, though small in market-size (<$25M in 2018), is expected to grow at a 49% CAGR over the next five years, with demand driven by markets like telecom & infrastructure, automotive, and mobile.

In terms of applications, mobile & consumer constituted 84% of the total advanced packaging market in 2018. This application will grow at a 5% CAGR (2018 - 2024), accounting for 72% of advance packaging units by 2024. In terms of revenue, telecom & infrastructure is the advanced packaging market’s fastest-growing segment (~28%), and it will double its market share from 6% in 2018 to 15% by 2024. Meanwhile, the automotive & transportation segment will increase its share from 9% to 11% by 2024.

CHANGES IN THE SEMICONDUCTOR SUPPLY CHAIN, SHIFTING BUSINESS MODELS, AND UNCERTAINTY RELATED TO US-CHINA TRADE CREATES OPPORTUNITIES FOR SOME, WHILE POSEING A THREAT TO OTHERS

Amidst an evolving business environment, the semiconductor supply chain is undergoing change at various levels. Some players have successfully managed to expand into a new business model and significantly impact the IC manufacturing chain, while others have failed to take off. Different players have different motivations to move or expand into new businesses - for example, software players like Google, Microsoft, Facebook, and Alibaba are designing their own processors in order to have system-level integration/customization and control of the supply chain up to assembly level. The biggest change is marked by foundries expanding into the advanced packaging business. Though they are relative newcomers, their impact has been significant. TSMC leads for innovation in the fan-out and 3D advanced packaging platforms, with various offerings such as InFO (and its variants), CoWoS, WoW, 3D SoIC, and more. For TSMC, advanced packaging has become a full-fledged business, and the company expects $3B revenue from its advanced packaging activities in 2019, which would put them fourth among OSATs. Elsewhere, UMC is a key supplier of Si interposers for 2.5D packaging, and recently partnered with Xperi to optimize and commercialize ZiBond and DBI technologies for a wide range of semiconductor devices. Meanwhile, XMC provides 3D IC TSV packaging for image sensors and high-performance applications. Overall, these players are instrumental in moving packaging from substrate to a silicon platform. IC substrate and PCB manufacturers like SEMCO, Unimicron, AT&S, and Shinko are entering the advanced packaging arena with panel-level fan-out packages and embedded dies (and passives) in organic substrates, and are eating the lunch of OSATs - especially those involved in the advanced packaging business. To remain competitive, we will see lots of M&A activity in the OSAT sector in the coming years, at various levels: consolidation amongst big players, the merger or acquisition of two midsize players with complementary...
services offerings (i.e. between pure packaging and testing players), and small OSATs (or WLP houses) being acquired by big players. Niche WLP players like Deca Technologies and LB Semicon are strong candidates for acquisition.

Trade tension between the U.S. and China could potentially disrupt semiconductor growth and cast uncertainty over the supply chain. The picture is still unclear and there is lots of confusion, intermingled with many “ifs” and “buts”. Multiple scenarios are possible depending on whether there is an all-out trade war or if a new trade deal is reached, either with concessions from each side or the status quo being maintained. It is also possible that this trade war will see assembly supply chains shifting from China to Taiwan, Korea, and Southeast Asia.

Once the traditional domain of OSATs and IDMs, a paradigm shift is occurring today in the packaging/assembly sphere. Players from different business models (foundries, substrate/PCB suppliers, EMS/DMs) are arriving and cannibalizing OSATs’ share. All of these supply chain shifts and their implications, along with the production of >25 major packaging suppliers per advanced packaging platform, are summarized and analysed in Yole’s report. Deeper insight into financial performance enables us to create a link between technology evolution, supply chain shifts, and the overall success of individual players in this changing landscape. Furthermore, this report offers a closer look at the financial evolution of the top 25 OSATs over 2013 - 2018. Yole also investigates the various facets of the US-China trade war and its potential effect on the semiconductor supply chain (including assembly and packaging), taking into account whether a clear-cut winner/loser scenario emerges. COMpanIES CITED IN THE REPORT (non exhaustive list)

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From A to Z…
Over the course of more than 20 years, Yole Développement has grown to become a group of companies. Together with System Plus Consulting and KnowMade, we now provide marketing, technology and strategy consulting, media and corporate finance services, reverse costing, structure, process and cost analysis services and well as intellectual property (IP) and patent analysis. Together, our group of companies is collaborating ever closer and therefore will offer, in 2019, a collection of over 125 reports, 10 new monitors and 120 teardowns. Combining respective expertise and methodologies from the three companies, they cover:

- MEMS & Sensors
- RF devices & technologies
- Medical technologies
- Semiconductor Manufacturing
- Advanced packaging
- Memory
- Batteries and energy management
- Power electronics
- Compound semiconductors
- Solid state lighting
- Displays
- Software
- Imaging
- Photonics

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- An analysis of your product market and technology
- A review of how your competitors are evolving
- 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

Our reports and monitors are for you!

Our team of over 70 analysts, including PhD and MBA qualified industry veterans from Yole Développement, System Plus Consulting and KnowMade, collect information, identify trends, challenges, emerging markets, and competitive environments. They turn that information into results and give you a complete picture of your industry's landscape. In the past 20 years, we have worked on more than 2,000 projects, interacting with technology professionals and high-level opinion makers from the main players of their industries and realized more than 5,000 interviews per year.

WHAT TO EXPECT IN 2019?
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!
18 fields of excellence combined with six markets to provide a complete picture of your industry landscape

**Market – Technology – Strategy – by Yole Développement**

Yole Développement (Yole) offers market reports including quantitative market forecasts, technology trends, company strategy evaluation and in-depth application analyses. Yole will publish more than 55 reports in 2019, with our partner PISEO contributing to some of the lighting reports.


The Reverse Costing® report developed by System Plus Consulting provides full teardowns, including detailed photos, precise measurements, material analyses, manufacturing process flows, supply chain evaluations, manufacturing cost analyses and selling price estimations. The reports listed below are comparisons of several analyzed components from System Plus Consulting. More reports are however available, and over 60 reports will be released in 2019. The complete list is available at www.systemplus.fr.

**Patent Reports – by KnowMade**

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.

The markets targeted are:
- Mobile & Consumer
- Automotive & Transportation
- Medical
- Industrial
- Telecom & Infrastructure
- Defense & Aerospace

Linked reports are dealing with the same topic to provide a more detailed analysis.
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### MEMS & SENSORS

- **MARKET AND TECHNOLOGY REPORT**
  - Status of the MEMS Industry 2019 - Update
  - Status of the Audio Industry 2019 - New
  - Uncooled Infrared Imagers and Detectors 2019 – Update
  - Consumer Biometrics: Technologies and Market Trends 2018
  - MEMS Pressure Sensor Market and Technologies 2018
  - Gas & Particle Sensors 2018

- **STRUCTURE, PROCESS & COST REPORT**
  - MEMS & Sensors Comparison 2019
  - MEMS Pressure Sensor Comparison 2018
  - Particle Sensors Comparison 2019
  - Miniaturized Gas Sensors Comparison 2018

- **PATENT REPORT**
  - MEMS Foundry Business Portfolio 2019 - New
  - Miniaturized Gas Sensors 2019 - New

### PHOTONIC AND OPTOELECTRONICS

- **MARKET AND TECHNOLOGY REPORT**
  - Silicon Photonics and Photonic Integrated Circuits 2019
  - LiDARs for Automotive and Industrial Applications 2019 - Update

- **PATENT REPORT**
  - Silicon Photonics for Data Centers: Optical Transceiver 2019 - New
  - LiDAR for Automotive 2018

### RF DEVICES AND TECHNOLOGIES

- **MARKET AND TECHNOLOGY REPORT**
  - 5G's Impact on RF Front-End Module and Connectivity for Cell Phones 2019 – Update
    - 5G Impact on Telecom Infrastructure 2019 - New
    - Radar and Wireless for Automotive: Market and Technology Trends 2019 - Update
    - Passive & Active Antenna Systems for Telecom Infrastructure 2019 - New
    - RF Standards and Technologies for Connected Objects 2018

- **STRUCTURE, PROCESS & COST REPORT**
  - RF Front-End Module Comparison 2019 - Update
    - Automotive Radar RF Chipset Comparison 2018

- **PATENT REPORT**
  - Antenna for 5G Wireless Communications 2019 - New
  - RF Front End Modules for Cellphones 2018
  - RF Filter for 5G Wireless Communications: Materials and Technologies 2019
  - RF GaN 2019 – Patent Landscape Analysis

*Update: 2018 version still available*
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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 Technologies for Sensing 2019 - Update
  - Status of the CCM and WLO Industry 2019 – Update
  - 3D Imaging & Sensing 2018
  - Machine Vision for Industry and Automation 2018
  - Sensors for Robotic Vehicles 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

#### MICROFLUIDICS

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

- **PATENT REPORT**
  - Microfluidic Manufacturing Technologies 2019 – New
  - Nanopore Sequencing 2019

#### 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

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

#### 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

- **STRUCTURE, PROCESS & COST REPORT**
  - Piezoelectric Materials from Bulk to Thin Film Comparison 2019
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BIOTECHNOLOGIES
- MARKET AND TECHNOLOGY REPORT
  - CRISPR-Cas9 Technology: From Lab to Industries 2018
- PATENT REPORT
  - Personalized Medicine 2019 – New

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
  - Hardware and Software for Artificial Intelligence (AI) in Consumer Applications 2019 - Update
  - Image Signal Processor and Vision Processor Market and Technology Trends 2019
  - xPU (Processing Units) for Cryptocurrency, Blockchain, HPC and Gaming 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
  - 3D TSV Integration and Monolithic Business Update 2019 - Update
  - Advanced RF SiP for Cellphones 2019 - Update
  - Status of the Advanced Packaging Industry 2019 - Update
  - Status of the Advanced Substrates 2019 - Update
  - Panel Level Packaging Trends 2019 - Update
  - Automotive Packaging Market & Technology Trends 2019 - New
  - Trends in Automotive Packaging 2018
  - Thin-Film Integrated Passive Devices 2018
- STRUCTURE, PROCESS & COST REPORT
  - Advanced RF SiP for Cellphones Comparison 2019
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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

- **STRUCTURE, PROCESS & COST REPORT**
  - Wafer Bonding Comparison 2018

- **PATENT REPORT**
  - Hybrid Bonding for 3D Stack 2019 – New

SOLID STATE LIGHTING

- **MARKET AND TECHNOLOGY REPORT**
  - Status of the Solid State Light Source Industry 2019 - New
  - Edge Emitting Lasers (EELS) 2019 - New
  - Light Shaping Technologies 2019 - New
  - Automotive Advanced Front Lighting Systems 2019 - New
  - VCSELs – Market and Technology Trends 2019 - Update

- **STRUCTURE, PROCESS & COST REPORT**
  - 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

- **PATENT REPORT**
  - VCSELs 2018

DISPLAY

- **MARKET AND TECHNOLOGY REPORT**
  - Next Generation 3D Displays 2019 - New
  - Next Generation Human Machine Interaction (HMI) in Displays 2019 - New
  - Micro-and Mini-LED Displays 2019 - Update
  - Displays & Optical Vision Systems for VR, AR & MR 2018

- **PATENT REPORT**
  - MicroLED Displays : Intellectual Property Landscape 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 Passive Components for the Power Electronics Industry 2019 - Update
  - Status of the Inverter 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
  - Li-ion Battery Packs for Automotive and Stationary Storage Applications 2019 - Update

- 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
  - Status of the Compound Semiconductor Industry 2019 - New
  - InP Materials, Devices and 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

Update: 2018 version still available
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 Q3 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 Q3 2019*

**CAMERA MODULE – 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 2019, the monitor will include an Excel database report for each phone and a quarterly comparison.
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 epiwafers, GaN-on-SiC, silicon, sapphire or diamond, semiconductor devices such as transistors, 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 epiwafers, 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

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<td>i-Micronews e-newsletter</td>
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<td>Brand visibility, networking opportunities</td>
<td>Targeted audience involvement equals clear, concise perception of your company's message.</td>
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<td>FreeFullPDF.com</td>
<td>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.</td>
<td>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.</td>
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**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

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

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

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