VCSELs - Market and Technology Trends 2019

Market and Technology Report 2019
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<td>- LiDAR principles and components</td>
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If your needs are OUT OF THE REPORT’S SCOPE:

What is not in the report could be subject to a custom analysis. Please contact our CUSTOM PROJECT SERVICES:

Jérome Azémar, Technical Project Development Director
Email: azemar@yole.fr - +33 6 27 68 69 33
REPORT OBJECTIVES

Specific objectives of this report are the following:

• Provide market data on different VCSEL applications
  • Volume and revenue by application and by market segment
  • Average selling price (ASP) and expected evolution
  • Ranking of top-5 VCSEL manufacturers

• Deliver a deep understanding of the VCSEL business value chain, players and trends:
  • Global list of VCSEL manufacturers
  • Supply chain information for mobile applications: who supplies to whom
  • Supply chain analysis
  • Comparison of VCSELs used in mobile applications

• Give insights on manufacturing and associated challenges
  • What is a VCSEL?
  • Analysis of epiwafers players
  • Insights on critical steps in VCSEL manufacturing
ABOUT THE AUTHORS

Biographies & contacts

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Pierrick Boulay works as a market and technology analyst in the fields of LED, OLED and lighting systems. He performs technical, economic, and marketing analyses at Yole Développement, the ‘More than Moore’ market research and strategy consulting company. He has industry experience in LED lighting, including general and automotive lighting, and OLED lighting.

Prior to Yole, Pierrick worked in several R&D departments for LED lighting applications. He holds a master’s degree in Electronics from ESEO in France.

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Pars MUKISH

Pars Mukish holds a master’s degree in Materials Science and Polymers from ITECH in France and a master’s degree in Innovation and Technology Management from EM Lyon, also in France. He works at Yole Développement, the ‘More than Moore’ market research and strategy consulting company, as senior market and technology analyst in the fields of LED, OLED, lighting technologies, and compound semiconductors. He performs technical, economic, and marketing analyses. In 2015, Pars was named business unit manager for emerging sapphire, LED/OLED, and display/lighting activities.

Previously, he worked as marketing analyst and techno-economic analyst at CEA, a French research center for several years.

Contact: mukish@yole.fr
COMPANIES CITED IN THIS REPORT

VCSEL OVERVIEW

Definitions

- The laser diode family falls into **two basic structures**:
  - **EELs** which emit from the edge of their structure.
  - **SELs** which emit from the top or bottom of their structure.

- **VCSEL** is the acronym for **vertical cavity surface emitting lasers** which are considered to be SELs.

- SELs have a **more complex structure than EELs**. The resonant cavity must be built using **up to 40 epitaxial layers** of p-type and n-type material and **various optical materials to create a Bragg reflector** that uses the different refractivity of material layers to create full mirrors at the bottom and partial mirrors at the top.

- **VCSELs can be packaged in surface-mount devices (SMDs)** like light-emitting diodes (LEDs) or in **TO-46 packages**. A VCSEL array is usually hermetically sealed in a package with an optical element.

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**Surface emitting laser**

**VCSEL in TO-46 package**

**VCSEL in SMD package**

---

Source: Philips Photonic

Source: The Optical Society of America
### VCSEL LANDSCAPE

Classification of systems embedding VCSELs by market segment

<table>
<thead>
<tr>
<th>Classification</th>
<th>Mobile and consumer</th>
<th>Automotive and transportation</th>
<th>Telecom and infrastructure</th>
<th>Medical</th>
<th>Industrial</th>
<th>Defense and aerospace</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Mobile&lt;br&gt;• Xxx&lt;br&gt;• Xxx&lt;br&gt;• Xxx</td>
<td>• Xxx&lt;br&gt;• Xxx</td>
<td>• Datacenter&lt;br&gt;• Xxx&lt;br&gt;• Xxx</td>
<td>• Xxx&lt;br&gt;• Xxx</td>
<td>• Xxx&lt;br&gt;• Xxx</td>
<td>• Surveillance camera</td>
</tr>
</tbody>
</table>
VCSEL MARKET

2018 – 2024 VCSEL market forecast

A 31% CAGR is expected in the next 6 years with mobile and consumer applications driving the market.

2018: $738M

2024: $3,775M

- Total market
- Mobile and consumer
- Automotive and transportation
- Telecom and infrastructure
- Medical
- Industrial
- Defense and aerospace

CAGR: 31%

2018:
- $92M
- $89M
- $4M
- $0.1M
- $0.1M

2024:
- $3,382M
- $30M
- $120M
- $238M
- $5M
- $0.3M

Total market
Mobile and consumer
Automotive and transportation
Telecom and infrastructure
Medical
Industrial
Defense and aerospace
Datacom was the first mass application for VCSELs. Today consumer applications are increasing the demand for such devices. In the next few years, automotive and industrial applications should generate even more demand and volume.

Market growth drivers

- **1st growth driver**: Datacom
- **2nd growth driver**: Optical mice
- **3rd growth driver**: 3D sensing
- **4th growth driver**: LiDAR

**Use of VCSELs**

- **Additive manufacturing**
- **In-cabin monitoring**

**Market**

- **1996**: $738M
- **2023**: $3,775M

**Time**

- 2014
- 2020

**Acceleration**: The speed of technology change accelerates.
VCSEL MARKET

Total VCSEL cost in smartphones

<table>
<thead>
<tr>
<th>Year</th>
<th>Functionalities</th>
<th>Total VCSEL cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>2016</td>
<td>Proximity sensing</td>
<td>$0.1</td>
</tr>
<tr>
<td>2017</td>
<td>Proximity sensing + Front 3D sensing (structured light)</td>
<td>$4 - 5</td>
</tr>
<tr>
<td>2018</td>
<td>Proximity sensing + Front 3D sensing (structured light)</td>
<td>$2 - 3</td>
</tr>
<tr>
<td>2019</td>
<td>Rear 3D sensing (ToF)</td>
<td>$1.5 – 2.5</td>
</tr>
<tr>
<td>2024</td>
<td>Proximity sensing + front 3D sensing + rear 3D sensing</td>
<td>~$2</td>
</tr>
</tbody>
</table>
# VCSEL MANUFACTURING

## VCSELs for mobile applications

<table>
<thead>
<tr>
<th>VCSEL*</th>
<th>Surface</th>
<th>Manufacturer</th>
<th>Function</th>
<th>Which smartphone?</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.017 mm²</td>
<td>Trumpf</td>
<td>Laser ranger</td>
<td>iPhones and many others</td>
<td>Proximity sensor</td>
</tr>
<tr>
<td></td>
<td>0.94 mm²</td>
<td>ams</td>
<td>Laser ranger</td>
<td>Huawei Mate 30 Pro</td>
<td>Face recognition</td>
</tr>
<tr>
<td></td>
<td>0.50 mm²</td>
<td>Lumentum</td>
<td>Flood Illuminator</td>
<td>iPhone X and beyond</td>
<td>Face recognition</td>
</tr>
<tr>
<td></td>
<td>0.60 mm²</td>
<td>ams</td>
<td>Flood Illuminator</td>
<td>Xiaomi Mi8</td>
<td>Face recognition</td>
</tr>
<tr>
<td></td>
<td>0.63 mm²</td>
<td>Trumpf</td>
<td>Dot projector</td>
<td>Huawei Mate 30 Pro</td>
<td>Face recognition, Coupled with a lens bar</td>
</tr>
<tr>
<td></td>
<td>0.64 mm²</td>
<td>Lumentum</td>
<td>Dot projector</td>
<td>Oppo Find X</td>
<td>Face recognition, Coupled with an active DOE</td>
</tr>
<tr>
<td></td>
<td>0.67 mm²</td>
<td>ams</td>
<td>Dot projector</td>
<td>Huawei Mate 30 Pro</td>
<td>Face recognition, Coupled with an active DOE</td>
</tr>
<tr>
<td></td>
<td>1.12 mm²</td>
<td>Lumentum</td>
<td>Dot projector</td>
<td>iPhone X and beyond</td>
<td>Face recognition</td>
</tr>
<tr>
<td></td>
<td>1.75 mm²</td>
<td>ams</td>
<td>Flood Illuminator</td>
<td>Vivo Nex Dual Display</td>
<td>Rear 3D sensing, Combined with a near IRF camera</td>
</tr>
<tr>
<td></td>
<td>2.18 mm²</td>
<td>ams</td>
<td>Dot projector</td>
<td>Xiaomi Mi8</td>
<td>Face recognition, The VCSEL is coupled with a patterned window. Less efficient compared to others</td>
</tr>
</tbody>
</table>

*The size of the VCSELs has been increased 10 times*
# EPIHOUSES ANALYSIS

**Landscape of GaAS VCSEL Epi - Existing players and potential new entrants**

<table>
<thead>
<tr>
<th>Pure Epihouse</th>
<th>VCSEL foundry with Epi capacity/capability</th>
<th>VCSEL IDM with Epi capacity</th>
<th>VCSEL Fabless with Epi know how</th>
<th>LED players</th>
<th>GaAs RF devices manufacturer with epi capability</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="IQE" /></td>
<td><img src="image" alt="Win Semiconductors" /></td>
<td><img src="image" alt="Lumentum" /></td>
<td></td>
<td><img src="image" alt="Osram" /></td>
<td><img src="image" alt="Epistar" /></td>
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<tr>
<td><img src="image" alt="IntelliEPI" /></td>
<td><img src="image" alt="Infineon" /></td>
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<td><img src="image" alt="Lxter" /></td>
<td><img src="image" alt="Lexar" /></td>
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</tbody>
</table>

©Yole Développement – 2019
The majority of VCSEL players are in the telecom and infrastructure segment followed by mobile and consumer segment. Some players focus only on one application whereas others target multiple ones.
VCSEL INDUSTRY - TRENDS

A new wave of investment and M&A has already started

Booming consumer 3D sensing applications have created another wave of investment and M&A in the VCSEL industry which is still ongoing.

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During 2018, five new smartphones have been released with 3D sensing modules. As of Q2-2019, five new smartphones have already been released and it is likely to continue.

In January 2017, Asus presented its Zenfone AR compatible with Google Tango.

In November 2017, Apple 3D face interaction iPhone X (Front 7Mp + 1.4Mp GS)

In May 2018, Xiaomi announced Mi8 with 3D sensing.

In November 2018, Huawei presented its Mate 20 Pro with front 3D sensing.

In October 2018, Huawei presented its Mate 30 Pro with a rear ToF module.

In November 2018, Oppo released the RX17 pro with a rear ToF module.

In April 2019, Oppo released the Reno with a rear ToF module.

In April 2019, Samsung released the A80, and A60 with a rear ToF module.

In March 2019, Huawei presented its Mate 30 Pro with a rear ToF module.

In February 2019, LG presented G8 ThinQ with a front ToF camera.

In March 2019, Huawei presented its Mate 20 Pro with front 3D sensing.

In April 2019, Oppo released the Reno with a rear ToF module.

In June 2016, Lenovo presented its Phab 2 Pro compatible with Google Tango.

In June 2018, Oppo announced the Find X with 3D sensing technology.

In June 2018, Vivo presented its 3D sensing technology.

In September 2018, Apple released the XR, XS and XS Max with a front 3D sensing module.
### QUALIFICATION STATUS OF VCSEL MANUFACTURERS FOR 3D SENSING

#### SUPPLY CHAIN ANALYSIS

Three main suppliers for smartphone are emerging...

<table>
<thead>
<tr>
<th>R&amp;D</th>
<th>Qualification</th>
<th>Mass production</th>
<th>What for?</th>
<th>Customer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lumentum</td>
<td>Xxx</td>
<td>Xxx</td>
<td>Dot projector</td>
<td>Apple</td>
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<td>Xxx</td>
<td>Xxx</td>
<td>Flood illuminator</td>
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<td>?</td>
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</tbody>
</table>

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Who is supplying Honor and Samsung?
SUPPLY CHAIN ANALYSIS

Positioning of new entrants (1/3)

New entrants will mostly position themselves as ...

- With a bright business perspective, the VCSEL business is attracting several new entrants coming from the LED industry and start-up eyeing on VCSEL potential.
  - Xxx
    - Xxx
  - Xxx
    - Xxx

**Attractiveness of VCSEL business**
MARKET FORECASTS
VCSEL in smartphone comparison 2019

Orbbec’s Front 3D Depth Sensing System in the Oppo Find X

Sony’s 3D Time-of-Flight Depth Sensing Camera Module
Yole Développement

From Technologies to Market
YOLE DEVELOPPEMENT – FIELDS OF EXPERTISE

Life Sciences & Healthcare
- Microfluidics
- BioMEMS & Medical Microsystems
- Inkjet and accurate dispensing
- Solid-State Medical Imaging & BioPhotonics
- BioTechnologies

Power & Wireless
- RF Devices & Technologies
- Compound Semiconductors & Emerging Materials
- Power Electronics
- Batteries & Energy Management

Semiconductor & Software
- Package, Assembly & Substrates
- Semiconductor Manufacturing
- Memory
- Software & Computing

Photonics, Sensing & Display
- Solid-State Lighting
- Display
- MEMS, Sensors & Actuators
- Imaging
- Photonics & Optoelectronics
4 BUSINESS MODELS

- **Consulting and Analysis**
  - Market data & research, marketing analysis
  - Technology analysis
  - Strategy consulting
  - Reverse engineering & costing
  - Patent analysis
  - Design and characterization of innovative optical systems
  - Financial services (due diligence, M&A with our partner)

- **Syndicated reports**
  - Market & technology reports
  - Patent investigation and patent infringement risk analysis
  - Teardowns & reverse costing analysis
  - Cost simulation tool: [www.i-Micronews.com/reports](http://www.i-Micronews.com/reports)

- **Monitors**
  - Monthly and quarterly update
  - Excel database covering supply, demand, and technology
  - Price, market, demand and production forecasts
  - Supplier market shares: [www.i-Micronews.com/reports](http://www.i-Micronews.com/reports)

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- Patent assessment
  
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**Piseo**

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**Blumorpho**

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- Technology and Market Report
- Leadership Meeting
- Q&A Service
- Meet the Analyst
- Custom Analysis

Depth of the analysis vs. Breadth of the analysis.
Our analysts provide market analysis, technology evaluation, and business plans along the entire supply chain.
SERVING MULTIPLE INDUSTRIAL FIELDS

We work across multiple industries to understand the impact of More-than-Moore technologies from device to system.

From A to Z...

- Industrial and defense
- Medical systems
- Energy management
- Automotive
- Transportation makers
- Mobile phone and consumer electronics
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 tear downs. 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

If you are looking for:
- 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 3,000 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 tear downs 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!
OUR 2019 REPORTS COLLECTION (1/4)

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 indepth 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.
OUR 2019 REPORTS COLLECTION (1/5)

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

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 Wireless Infrastructure 2019 - New
  - Radar and Wireless for Automotive: Market and Technology Trends 2019 - Update
  - Advanced RF Antenna Market & Technology 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

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

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 2018
  - Liquid Biopsy: from Isolation to Downstream Applications 2018
  - Chinese Microfluidics Industry 2018

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

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 Materials 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 Diagnostic - 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 Advanced Packaging Industry 2019 - Update
  - Status of Advanced Substrates 2019 - Update
  - Panel Level Packaging Trends 2019 - Update
  - System in Package (SiP) Technology and Market 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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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 Lithography 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

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 - Technology, Industry and Market 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
- VCSELs 2018

STRUCTURE, PROCESS & COST REPORT
- VCSEL Comparison 2019

PATENT REPORT
- VCSELs 2018

DISPLAY

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

PATENT REPORT
- MicroLED Displays : Intellectual Property Landscape 2018

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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
  - 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

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#### 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

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#### 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 Epitwaffer Market: RF, Photonics, LED and PV Applications 2018

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

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*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.
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-Coalt (NMC), Lithium Cobalt Aluminium Oxide (NCA), Lithium Nickel Metal Dioxide (LiNiMO2), Lithium Metal Phosphate (LiIMPO4), 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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- #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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