Status of the Camera Module Industry 2019
Focus on Wafer Level Optics

2019 Report Sample
REPORT OBJECTIVES

1. To provide market data on key CCM metrics & dynamics.
   - CCM revenue forecast, volume shipments and component share.
   - Market share with detailed breakdown by player.
   - Application focus on key areas of growth for CCM: Mobile and Automotive.

2. To provide in-depth understanding of the CCM value chain, infrastructure & players.
   - Who are the CCM players (CIS manufacturers, CCM manufacturers, Optics manufacturers…) and how they are related?
   - Who are the key suppliers to watch and more generally how will the Camera Module industry evolve.

3. To provide key technical insight & analysis about future technology trends and challenges.
   - Manufacturing technologies: design structure.
   - Device technologies: CCM application across markets.
   - Technology focus on game changing areas such as OIS and dual cameras.
Yole’s market forecast model is based on matching heterogenous sources:

- **Comparison with existing data**
- **Monitoring of corporate communication**
- **Comparison with publicly available data**
- **Yole screening**

**Top-to-bottom approach**
- Aggregate of market forecasts @ system level

**Bottom-up approach**
- Aggregate of main players’ revenue @ system level

**Reconciliation**
- Market Segmentation
  - Volume (in Munits)
  - ASP (in $)
  - Revenue (in $M)

**Preexisting information**
- **Primary data**
  - Reverse costing
  - Patent analysis
  - Annual reports
  - Direct interviews

- **Secondary data**
  - Press releases
  - Industry organization
  - Conferences

**Bottom-up approach**
- Ecosystem analysis
- Aggregate of key players’ revenue @ semiconductor device level

**Semiconductor foundry activity**
- Capacity investments and equipment needs

**Comparison with prior Yole reports**
- Recursive dataset improvement
- Customer feedback
WHAT IS TAKEN INTO ACCOUNT IN THE ANALYSIS?
From sub-components to camera modules

Camera minimum resolution
50 pixel x 50 pixel

Analysis from the sub component point of view.

Optics
AF&OIS
Module Assy
Sensor array
Illuminator

Wafers & raw material
Sub-components
Sensor, optics & illumination

Systems
Camera Modules

Courtesy of Sony
Courtesy of PMDTech
Courtesy of Apple

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Global Forecast
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- Key technology developments
- Plateauing Mobile situation 2017-2018
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Mobile trend
- 3D sensing: dedicated dual cameras for structured light sensors or time of flight sensors
- 3D sensing illuminators are benefiting from Wafer Level (WL) approaches
- Motion sensor: global shutter sensor (VGA to 1.3Mp; 3µm pixel)
- Chinese OEMs genuine approach to imaging is setting the trend
ABOUT THE AUTHORS OF THIS REPORT

Biography & contact details

**Pierre Cambou**

Pierre Cambou has been part of the imaging industry since 1999. He first took several positions at Thomson TCS, which became Atmel Grenoble in 2001 and e2v Semiconductors in 2006. In 2012 Pierre founded Vence Innovation, later renamed Irlynx, to bring to market an infrared sensor technology for smart environments and interactions. He has an Engineering degree from Université de Technologie de Compiègne and a Master of Science from Virginia Tech. Pierre also graduated with an MBA from Grenoble Ecole de Management. In 2014 he joined Yole Développement as Imaging Activity Leader. Contact: cambou@yole.fr

**Jean-Luc Jaffard**

From 1966 Jean-Luc Jaffard paved the way for imaging activity at STMicroelectronics being at the forefront of the emergence and growth of this business. At STMicroelectronics Imaging Division he was appointed as Research Development and Innovation Director managing a large multidisciplinary and multicultural team. He was promoted to Deputy General Manager and Advanced Technology Director in charge of identifying and developing breakthrough Imaging Technologies and transforming them into innovative and profitable products. In 2010 he was appointed STMicroelectronics Intellectual Property Business Unit Director. In January 2014 he created the Technology and Innovation branch of Red Belt Conseil.
WHAT WE GOT RIGHT, WHAT WE GOT WRONG

CCM forecast over the years

Yole has lowered its forecast for CMOS camera modules due to slow down of the smartphone sales and impact of increased Chinese leadership commending competition on price.

Growth potential is maintained at a high level for the 2019-2024 period, mostly driven by multiple camera approaches and the introduction of advanced camera technologies in smartphones.

Our goal is a +/-10% market prediction in five years’ time.
HOW IS A MOBILE CAMERA MODULE MADE?

Structure of a mobile camera module

Once a relatively basic component, CCM has evolved into a complex micro-electro-mechanical device.

- Illumination
- Connector
- Flex-rigid substrate
- CMOS Image Sensor (CIS)
- VCM Driver
- Metal Shield
- Voice Coil Motor (VCM)
- Lenses & Spacers
- Lens Mount

Courtesy of Oppo
Combined revenues in the CCM business have reached $27.1B in 2018.

Revenues are captured by four types of players:
- CCM Assembly
- CIS Supplier
- Lens Supplier
- VCM Suppliers (AF&OIS)

$720M of these revenues are for illumination sub-modules.
CAMERA MODULE VOLUME SHIPMENT FORECAST 2012–2024

by market (in Munits)

CCM volume shipments have slowed down in synchronization with the smartphone market which represent 82% of volume.

5.1 Billion units shipped in 2018
Production should reach 8.0 Billion units in 2024

Medium term volume growth rate should see renewed traction ~7.8% CAGR 2018–2024 due to multiple camera approaches.
2018 CAMERA MODULE MARKET SHARE (IN %)

2018 Camera module market share (in %) by players

2017 $25.6B

2018 $27.1B

Fragmented marketplace
Slowly moving towards consolidation

Rank | Company | 2017 ($M) | 2018 ($M) | YoY(%) |
-----|---------|-----------|-----------|--------|
1    | LG Innotek | $3,068    | $3,395    | 10.7%  |
2    | Semco    | $2,860    | $3,390    | 18.5%  |
3    | Foxconn (Sharp) | $2,561 | $3,035    | 18.5%  |
4    | Sunny Optical | $2,500   | $2,400    | -0.0%  |
5    | O-Film   | $2,000    | $2,390    | 19.5%  |
6    | Luxvisions (Liteon) | $1,334  | $1,094    | -18.0% |
7    | Q-Tech   | $1,169    | $1,040    | -11.0% |
8    | ams      | $186      | $724      | 289%   |
9    | Primax   | $615      | $707      | 15.0%  |
10   | Chicony  | $650      | $700      | 7.7%   |
11   | Cowell   | $740      | $674      | -8.9%  |
12   | Partron  | $490      | $390      | -20.4% |

Next 5 | $1,830 | $1,820 | -0.5% |
Other  | $4,939 | $5,369 | 8.7% |
TOTAL  | $25,591 | $27,128 | 6.0% |

Other include: Mcore, Cammays, Chrisnty, Q-Tech, Truly, Hsungs Optics, Asia Optical, Powerlogic, Vistapoint

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Yole Developpement
ECOSYSTEM OF THE CAMERA MODULE INDUSTRY

2018 state of the industry

The CCM ecosystem has 12 companies with more than $1B in revenue.

Main players of the camera module industry

- **2018**
- **2017**

**Revenue ($M)**

- **Image sensor**
- **Module Assy**
- **Lens set**
- **VCM Assy**

**12 players beyond $1B**

**Next 12 players between $250M and $1B**

**Other players below $250B**

GLOBAL MARKET OUTLOOK

Smartphone market glitch

In 2011 and 2012 laptop PCs and digital cameras have peaked in the wake of the great recession, being disrupted by smartphones.

In 2018 we have reached smartphone market saturation and the outlook is now aligned with GDP growth outlook.
There are roughly 1,600M smartphones produced every year and 100M light vehicles.

The main factor governing the number of cameras produced worldwide is the average number of cameras per end product, mainly in smartphones and light vehicles.

In 2024, it is expected that both markets will have an average number of cameras per end product exceeding 3.0.
The supply chain is quite complex.
WHAT IS WAFER LEVEL OPTICS?

Collective optical component manufacturing

**Standard approach**
Polymer injection / Glass turning

**Wafer or panel based**
UV replication / embossing / etching
MOBILE PHONE MARKET TREND

Mobile phone cameras have become multi-sensor optronic interfaces.

The current market is still focused on computational approaches. Embedded 3D camera is the next step.

Number of sensors

- 1 sensor
  - Main and sub-camera
  - LED flash
- 2 sensors
  - Main and sub-camera
  - Range finder
  - LED flash
- 3 sensors
  - Main and sub-camera
  - Range finder
  - LED flash
- 3+ sensors
  - Main and sub-camera
  - Range finder
  - LED flash

Embedded 3D interactive
The world becomes interactive

- Dual rear and front-camera
- 3D mapping
- VR localization

Photography and video
Catching up with DSLR and video cameras

Courtesy of Sony

Embedded 3D computational
New embedded 3D imaging

Courtesy of Panono

Global camera module industry has reached $27.1B in 2018 and should reach $45.7B in 2024.

The CCM industry is growing at a pace of 7.8% in volume and 9.1% in revenues. The main drivers is the proliferation of cameras per mobile handsets and a similar trend in automotive.

Illumination modules for mobile is now a significant sub-market mainly serving 3D sensing cameras. They are using wafer level techniques initially developed for cameras.

Smartphone market maturation is creating a high competition environment in which cameras play a central role maintaining the momentum of the CCM industry.

Automotive has become a truly significant sub-market with 11% of revenues. Most camera module players have both mobile and automotive business. The future of video sensing is in part decided in this segment.

The camera module industry is a technology driven environment: The role of computing and artificial intelligence (AI) will play a growing role in the future. Two path will guide the future of AI driven cameras, one is using 5G with high bandwidth data gathering, and another will use specific edge computing & sensing technique such as neuromorphic approaches.
Mobile Camera Module Comparison 2019


Physical analysis and cost comparison of seven leading flagship smartphone cameras: Apple iPhone X/XS/XR, Samsung Galaxy S9, Huawei Mate 20 Pro and P20 Pro, Xiaomi Mi8 Explorer Edition, Oppo Find X and Vivo X21 UD.

More details here.

Bundle offer available - Contact us for more information.
RELATED REPORTS

Status of the CMOS Image Sensors Market

Consumer Biometrics: Market and Technologies Trends 2018

3D Imaging & Sensing 2018

STMicroelectronics ToF Proximity Sensor & Flood Illuminator in the Apple iPhone X

Intel RealSense D435 3D Active IR Stereo Depth Camera
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

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

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

**Photonic, 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/or Quarterly update
  - Excel database covering supply, demand, and technology
  - Price, market, demand and production forecasts
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  - Market, technology and strategy consulting
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- **System Plus Consulting**
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  - Cost simulation tools
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- **KnowMade**
  - IP analysis
  - Patent assessment
  - www.knowmade.fr

- **PISEO photonics innovation services**
  - Design and characterization of innovative optical systems
  - www.piseo.fr

- **Blumorpho**
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  - www.blumorpho.com

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OUR GLOBAL ACTIVITY

40% of our business

30% of our business

30% of our business
ANALYSIS SERVICES - CONTENT COMPARISON

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

Depth of the analysis vs. Breadth of the analysis

High

Low
SERVING THE ENTIRE SUPPLY CHAIN

Integrators, end-users and software developers

Device manufacturers

Suppliers: material, equipment, OSAT, foundries...

Financial investors, R&D centers

Our analysts provide market analysis, technology evaluation, and business plans along the entire supply chain.
We work across multiples industries to understand the impact of More-than-Moore technologies from device to system.

**SERVING MULTIPLE INDUSTRIAL FIELDS**

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

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 and 10 new monitors. 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. 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.
OUR 2019 REPORTS COLLECTION (1/5)

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- 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
  - Photonic Integrated Circuit 2019 - New
  - LiDARs for Automotive and Industrial Applications 2019 - Update
  - Silicon Photonics 2018
- 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
  - Radar and V2X Market & Technology for Automotive 2019 - Update
  - Advanced RF Antenna Market & Technology 2019 - New
- 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
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  - CMOS Image Sensors Comparison 2019
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  - Facial & Gesture Recognition Technologies in Mobile Devices 2019 - New
  - Apple iPhone X Proximity Sensor & Flood Illuminator 2018

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- MARKET AND TECHNOLOGY REPORT
  - X-Ray Flat Panel Detectors for Military, Industrial and Medical 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
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  - 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
- STRUCTURE, PROCESS & COST REPORT
- PATENT REPORT
  - Microfluidic Manufacturing Technologies 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
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  - Piezoelectric Materials from Bulk to Thin Film Comparison 2019
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- 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
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  - Artificial Intelligence Computing For Automotive 2019 - New
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- Status of the Memory Business 2019 - New
- MRAM Technology and Business 2019 - New
- Emerging Non-Volatile Memory 2018
- STRUCTURE, PROCESS & COST REPORT
  - Memory Comparison 2019
  - Magneto resistive 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 2019 - Update
  - Status of Advanced Substrates 2019 - Update
  - Panel Level Packaging Trends 2019 - Update
  - RF System-in-Package & Materials for 5G 2019
  - 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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### 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

- **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
  - QD and Wide Color gamut (WCG) Display Technologies 2019 - Update
  - Displays & Optical Vision Systems for VR, AR & MR 2018

- **PATENT REPORT**
  - MicroLED Displays: Intellectual Property Landscape 2018

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  - 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
- 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 Compound Semiconductor 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
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 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.

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**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 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 (LiNiMO2), 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.
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Contact: Camille Veyrier (veyrier@yole.fr), Marketing & Communication Director

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The camera module industry has reached a new stage in its development. With $27.1B of global revenues generated in 2018, Yole Développement expects it to maintain a 9.1% Compound Annual Growth Rate (CAGR) for the next 5 years. This industry, which covers image sensors, lenses, voice coil motors, illuminators and camera assemblies, will therefore reach $45.7B by 2024. The overall growth is a combination of mega trends. The main upward driver is the increasing number of cameras in products such as smartphones and cars. 3D sensing cameras are part of this trend, invading mobile devices, computing and automotive industries. If the nature of camera module making is unchanged with 3D sensing, illuminator sub-modules create a new market area. This brings new technologies, such as wafer level optics (WLO), along with it. The market for devices involved in illumination for 3D sensing accounted for $720M in 2018 and will expand ninefold within five years, reaching $6.1B by 2024. This is helping compensate for the shipment volume slowdown in smartphones, computers, tablet and digital cameras. While the complexity and cost of each individual camera is still increasing on average, reaching $5.5 per unit, we are now seeing more diversity. In recent years the distribution of resolution, optical format and camera type was only heading towards uniformly high specifications. But in 2018 the smartphone market has evolved quite dramatically. In an attempt to work around the increasing cost of imaging, mid-range phones have been implementing 2-5Mp formats that were previously fading away.

Despite headwinds the CMOS Camera Module (CCM) market remains highly attractive.

The camera module industry has reached a new stage in its development. With $27.1B of global revenues generated in 2018, Yole Développement expects it to maintain a 9.1% Compound Annual Growth Rate (CAGR) for the next 5 years. This industry, which covers image sensors, lenses, voice coil motors, illuminators and camera assemblies, will therefore reach $45.7B by 2024. The overall growth is a combination of mega trends. The main upward driver is the increasing number of cameras in products such as smartphones and cars. 3D sensing cameras are part of this trend, invading mobile devices, computing and automotive industries. If the nature of camera module making is unchanged with 3D sensing, illuminator sub-modules create a new market area. This brings new technologies, such as wafer level optics (WLO), along with it. The market for devices involved in illumination for 3D sensing accounted for $720M in 2018 and will expand ninefold within five years, reaching $6.1B by 2024. This is helping compensate for the shipment volume slowdown in smartphones, computers, tablet and digital cameras. While the complexity and cost of each individual camera is still increasing on average, reaching $5.5 per unit, we are now seeing more diversity. In recent years the distribution of resolution, optical format and camera type was only heading towards uniformly high specifications. But in 2018 the smartphone market has evolved quite dramatically. In an attempt to work around the increasing cost of imaging, mid-range phones have been implementing 2-5Mp formats that were previously fading away.

This report contains a special focus on the WLO industry. Several types of products are covered, such as lenses, diffusers, diffractive optical elements (DOEs), autofocus (AF) and optical image stabilization (OIS) tunable lenses. Such technologies have received huge investment between 2005 and 2010, aiming to serve cameras for mobile phones before the smartphone era. Due to the high image quality required by smartphones, WLO approaches were left aside until today. As previously forecasted, the addition of 3D sensing brought an opportunity for wafer level approaches to enter mass production and companies such as ams, Himax and AAC were able to.

Status of the Camera Module Industry 2019
Focus on Wafer Level Optics
Market & Technology report - February 2019

CMOS Camera Modules (CCM) have become a key sensor technology – what are the dynamics and strategies in this highly competitive market?

Key Features
- Updated forecasts
- Ecosystem analysis
- Technology update
- New trends and applications
- Special focus on Wafer Level Optics (WLO)

What’s New
- Cost erosion analysis
- Resolution of dual cameras
- 3D sensing penetration rate
- Illumination modules
The CCM ecosystem is extremely dynamic, new innovations are coming

With twelve companies with revenues above a billion dollars per annum and the next twenty companies above a hundred million dollars, the CCM industry provides opportunities for numerous players. In the last four years we have been monitoring the industry, and a few major trends have become obvious. First is the dominance of two heavyweights in image sensors and lenses, Sony and Largan, which cover up to 50% of the market’s needs. Now, these heavyweight companies are having their dominance challenged. The number of companies above one billion dollars per annum revenue is rising, while the number above one hundred million dollars is decreasing, showing that the ecosystem is getting more concentrated. The cost to enter is high and only breakthroughs such as 3D sensing allow new players and technologies to get in. The rhythm of mergers and acquisitions (M&A) has reached a climax in 2017, and now the lack of target companies has momentarily stopped acquisitions. The large camera module makers are looking to increase their margin. As new technologies get ready to enter we expect M&A to rise again in years to come, fueling the 9.1% CAGR in a virtuous cycle.
OBJECTIVES OF THE REPORT

- To provide market data on key CCM metrics and dynamics:
  - CCM revenue forecast, volume shipments and component share
  - Market share with detailed breakdown by player
- To provide in-depth understanding of the CCM value chain, infrastructure and players
- Who are the CCM players (CIS manufacturers, CCM manufacturers, Optics manufacturers…) and how they are related?
- To provide key technical insight and analysis about future technology trends and challenges:
  - Manufacturing technologies: design structure
  - Device technologies: CCM application across markets
  - Technology focus on game changing areas such as OIS and dual cameras

COMPANIES CITED IN THE REPORT (non exhaustive list)


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> Autofocus and OIS
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Conclusions

About Yole Développement

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Pierre Cambou has been part of the imaging industry since 1999. He first took several positions at Thomson TCS, which became Atmel Grenoble in 2001 and e2v Semiconductors in 2006. In 2012 Pierre founded Vence Innovation, later renamed Irymex, to bring to market an infrared sensor technology for smart environments and interactions. He has an Engineering degree from Université de Technologie de Compiègne and a Master of Science from Virginia Tech. Pierre also graduated with an MBA from Grenoble Ecole de Management. In 2014 he joined Yole Développement as Imaging Activity Leader.

Since 1966 Jean-Luc Jaffard has made invaluable contributions to imaging activity at STMicroelectronics, working at the forefront of this business’s emergence and impressive growth. At STMicroelectronics’ Imaging Division, Jean-Luc was appointed Research Development and Innovation Director, managing a large multidisciplinary/multicultural team. Soon after, he was promoted to Deputy General Manager and Advanced Technology Director, in charge of identifying and developing breakthrough imaging technologies and transforming them into innovative, profitable products. In 2010 he was appointed STMicroelectronics’ Intellectual Property Business Unit Director, and in January 2014 he created Red Belt Conseil’s Technology and Innovation branch.
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Status of the Camera Module Industry 2019 - Focus on Wafer Level Optics

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The present document is valid 24 months after its publishing date: February 28, 2019

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ABOUT YOLE DÉVELOPPEMENT

Founded in 1998, Yole Développement has grown to become a group of companies providing marketing, technology and strategy consulting, media and corporate finance services, reverse engineering and reverse costing services as well as IP and patent analysis. With a strong focus on emerging applications using silicon and/or micro manufacturing, the Yole group of companies has expanded to include more than 80 collaborators worldwide covering MEMS and Image Sensors, Compound Semiconductors, RF Electronics, Solid-State Lighting, Displays, Software, Optoelectronics, Microfluidics & Medical, Advanced Packaging, Manufacturing, Nanomaterials, Power Electronics and Batteries & Energy Management.

The “More than Moore” market research, technology and strategy consulting company Yole Développement, along with its partners System Plus Consulting, PISEO and KnowMade, support industrial companies, investors and R&D organizations worldwide to help them understand markets and follow technology trends to grow their business.

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7.2. In the event of breach by one Party under these conditions or to any contract (orders) entered into in writing. They shall be effective upon receipt by the other Party.

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8.2. The Seller, may, from time to time, update these Terms and Conditions. The Buyer agrees to be bound by any such change. The latest version of these terms and conditions, provided they have been communicated to him in due time.

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