Camera Module Industry 2017
ABOUT THE AUTHORS OF THIS REPORT

Biography & contact

**Pierre Cambou**

Pierre Cambou joined the imaging industry in 1999. Following an engineering degree from Université de Technologie de Compiègne and a master of science from Virginia Tech in 1998. He did graduate as well from Grenoble Ecole de Management’s MBA in 2010. Cambou took several positions at Thomson TCS, which became Atmel Grenoble in 2001 and e2v Semiconductors in 2006. In 2012 he founded Vence Innovation, now called Irlynx, in order to bring to market a disruptive man-to-machine interaction technology. He joined market research and strategy consulting company Yole Développement as imaging activity leader in 2014. Contact: cambou@yole.fr

**Jean-Luc Jaffard**

From 1966 Jean-Luc Jaffard paved the way of imaging activity at STMicroelectronics being at the forefront of the emergence and growth of this business. At STMicroelectronics Imaging Division he was successively appointed as Research Development and Innovation Director managing a large multidisciplinary and multicultural team and later on promoted to Deputy General Manager and Advanced Technology Director in charge of identifying and developing breakthrough Imaging Technologies and to transform 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.
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Yole has lowered its forecast for CMOS camera modules due to cost reductions and delayed introduction of new technologies such as OIS.

Mostly driven by dual-camera approaches and the introduction of advanced sensor technologies in smartphones, growth potential is maintained at a high level for the 2016-2022 period.

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

Structure of a Mobile camera module

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

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

Courtesy of Oppo

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HOW IS MADE AN AUTOMOTIVE CAMERA MODULE?

Structure of the automotive CCM

The automotive CCM has duplicated the formula from Mobile

Lens Mount

CMOS Image Sensor (CIS)

Flex rigids substrate

No voice coil motor

Connector

Lens

Complete ADAS camera system

Automotive camera module

Courtesy of TRW
Combined revenues in the CCM business reached $23.4B in 2016.

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

The industry is the reunion of different sub-part manufacturing.
Combined revenues in the CCM business has reached $23.4B in 2015 and should reach $46.8B in 2022.

The stacked sensor effect temporarily froze module size & price.

Growth is picking up again in 2017 due to full effect of OIS and Dual camera demand.

A $23B industry with double digit growth rate.
On the rear of the phone, the effort is still to match high-end digital photography cameras. Use of dual (computational) approach allowed for x2 zoom capability (Apple) and/or enhanced resolution black and white pictures (Huawei). OIS once thought to be the new Grail has in fact penetrated more slowly than expected due to unstructured supply chain, lack of market recognition and cost. Next steps are most probably incremental innovations with dual OIS, Laser rangers, and 3D computational capability.

On the front side of the phone, a race toward high resolution sensors for selfies has been observed. The new trend from Apple is transforming the front optical hub into a touchless user interface with 3D sensing capability. Next steps are therefore more disruptive on this side of the phone, with possible variations in technology choices.

- 3D mapping: dedicated dual sensors or structured light sensors or time of flight sensors
- LED Illuminator: probably a more complex device than current LED, possibly with MEMS mirror
- Motion sensor: global shutter sensor (VGA, pixel 3.5µm to 5µm)
- Iris recognition: could improve current biometric sensors approach
- Far Infrared: interaction with humans
- Hyperspectral: spectroscopic insights in the nature of objects
MOBILE MARKET TREND

3D Sensing camera is the fifth phase of smartphone camera evolution

The majority of demand is for 10mm x 10mm x 5mm modules

- **Camera phones:** Innovation from Sharp in June 2000
  - **Module size and cost:**
    - 20mm x 10mm: $20
    - 10mm x 10mm: $10
    - 5mm x 5mm: $5
    - 1mm x 1mm: $1

- **Smartphones:** The main camera’s size stops shrinking and a front-facing camera is added

- **Dual rear cameras:** Improved photography thanks to a dual-camera approach

- **Rear smartphone camera modules:**
  - $20B Market

- **Front smartphone camera module:**
  - $10B Market

- **Event #1**
  - **3D sensing module:** The front camera becomes a user interface
  - **3D sensing module:** Size increases

- **Market size:**
  - $20B
  - $10B
  - $5B
  - $1B

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2016 CCM REVENUE MARKET SHARE (IN $M)

Main players market share analysis
CONSUMER APPLICATIONS

VR/AR/MR are applications, not a specific hardware device

<table>
<thead>
<tr>
<th>Applications</th>
<th>Sensors</th>
<th>Hardware</th>
<th>VR headset</th>
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<th>Smartphone</th>
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</thead>
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<td>VR</td>
<td>Position sensor</td>
<td></td>
<td>[VR headset image]</td>
<td>[AR headset image]</td>
<td>[Notebook and tablet image]</td>
<td>[Smartphone image]</td>
</tr>
<tr>
<td>AR</td>
<td>2D camera</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>MR</td>
<td>3D camera</td>
<td></td>
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**MOBILE TECHNOLOGY TREND**

Additional optical sensor technologies in mobile devices  
(Source: Yole Développement, 2017)

<table>
<thead>
<tr>
<th>Players</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth sensing</td>
<td>accelerated development of 3D sensors pixel shrinks opens door to integration</td>
</tr>
<tr>
<td>3D Structured Light</td>
<td>Structured light is one approach to 3D sensing, effort mainly on the illuminator</td>
</tr>
<tr>
<td>NIR sensors</td>
<td>NIR sensors is also part of the 3D story</td>
</tr>
<tr>
<td>Iris or face recognition</td>
<td>Surfing on the wave of enhanced biometrics and ergonomics</td>
</tr>
<tr>
<td>Far Infrared sensors</td>
<td>FIR sensors have the size for mobile integration, the application is still missing</td>
</tr>
<tr>
<td>Hyperspectral sensors</td>
<td>Plasmonic or Fabry Perrot filters could bring hyperspectral capability to mobile</td>
</tr>
</tbody>
</table>
In 2015, Yole Développement published its first report on the camera module industry and mentioned the immaturity of the ecosystem with numerous small players especially for module assembly. Now the dust has settled and giant camera module players have emerged such as LG Innotek, Semco, Foxconn Sharp, O-Film and Sunny Optical. This 2017 edition is giving you the insights into the trajectory of the industry and of more than 30 players serving mobile and other applications such as automotive and security.

Historically one could differentiate the faith of camera module market from the sub parts such as the image sensor, the lens and the autofocus or optical image stabilization system (Voice Coil Motors - VCM). It seems that differentiated growth has now ended and every sub segment is enjoying almost equal benefit from the rising market tide. This convergence is in part due to the end of quasi-monopoly from Sony in the image sensor sub-segment now joined by Samsung and Omnivision. The story is very similar for Largan Precision in the lens set sub-segment which is now facing renewed competition from Sunny Optical, Kantatsu and Genious Optical. The last sub-domain of our interest in this report is VCMs. The growth of VCM companies has been undercut by dire structuration efforts. We had mentioned the inability of the VCM to serve the demand in the mobile market. Price pressures have changed the face of competition with competitors such as Mitsumi and Shicoh which were forced out and new players such as New Shicoh and Jawha to take center stage.
On the mobile front camera side, the impact of selfies has been increasing the performance and cost of camera devices. Now Apple and Samsung are coming out with dual front camera setup incorporating biometric capability and also adding a 3D sensing user interface for Apple. Those innovations are game changing as they explain the enormous increase in camera module content per smartphone. While 2 cameras were needed few years ago, now the new normal in the high end of mobile is to have 4 cameras, 2 on both sides. With a gross average cost of $6 per camera it is quite easy to understand we left a world of $12 per smartphone (in 2015) and have entered a world in the range of $24 worth of camera module per smartphone. This vision is currently being implemented by most OEMs and while the smartphone industry is entering into a more modest growth pattern due to maturity, the camera module industry is not slowing down its pace thanks to volume demand, sustained prices and a technology driven environment.

**AUTOMOTIVE CAMERA MODULES ARE REACHING $2 BILLIONS IN REVENUE AND ARE NOW WELL BEYOND EMERGENCE**

While 2016 has been a crazy year for automotive camera modules as it paused for a quarter and ended with the $15B purchase of Mobileye by Intel. The “explosive” growth pattern is maintained with 20% CAGR predicted for 2016-2022. In this context, the balance of power has gradually switched from the camera module makers who may have discussed directly with the OEMs, now replaced by the tier ones such as Bosch, Continental and Autoliv that do not necessarily manufacture the camera module themselves. Most camera module makers are in fact part of this game as tier twos. Automotive cameras are part of a bigger picture of automotive electronics, ADAS and automated driving. They have hugely benefited from the infrastructure left by Digital Still Camera (DSC) manufacturers and the know-how developed from mobile camera modules. The direct consequence has been the dramatic decrease in average selling prices (ASP) as we expect it to cross the $20 line in 2017. Technology wise we do also see much more maturity in the way automotive camera modules are build. As standardization is fostering competition, we expect more players to enter the fray. Today we are witnessing a duopoly on the image sensor side from ON Semiconductor and Omnivision. The link between image acquisition and image analysis is very strong in ADAS where ultimately all automotive cameras are build. As standardization is fostering competition, we expect more players to enter the fray. Today we are witnessing a duopoly on the image sensor side from ON Semiconductor and Omnivision. The link between image acquisition and image analysis is very strong in ADAS where ultimately all automotive cameras will be categorized. One of the big question is the future compatibility of vision processors and the evolution in market dominance of vendors such as Intel Mobileye.

**COMPANIES CITED IN THE REPORT (non exhaustive list)**

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KEY FEATURES OF THE REPORT
• 2016 camera module market share (in %)
• 2016 sensor for CCM market share (in %)
• 2016 lens for CCM market share (in %)
• 2016 autofocus & OIS for CCM market share (in %)
• CCM volume shipment forecast by application 2012-2022
• CCM average selling price forecast by application 2012-2022
• CCM revenue forecast by application 2012-2022

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  - Thin Wafer Processing and Dicing Equipment Market 2016
  - Emerging Non Volatile Memories 2016

- **COMPOUND SEMICONDUCTORS**
  - Power GaN 2016: Epitaxy and Devices, Applications and Technology Trends
  - Sapphire Applications & Market 2016: from LED to Consumer Electronics
  - Power SiC 2016: Materials, Devices, Modules, and Applications

- **LED**
  - UV LED Technology, Manufacturing and Applications Trends 2016
  - Organic Thin Film Transistor 2016: Flexible Displays and Other Applications
  - Sapphire Applications & Market 2016: from LED to Consumer Electronics

- **POWER ELECTRONICS**
  - Power Electronics for EV/HEV 2016: Market, Innovations and Trends
  - Status of Power Electronics Industry 2016
  - Passive Components Technologies and Market Trends for Power Electronics 2016
  - Power SiC 2016: Materials, Devices, Modules, and Applications
  - Power GaN 2016: Epitaxy and Devices, Applications, and Technology Trends
  - Inverter Technologies Trends & Market Expectations 2016
  - Opportunities for Power Electronics in Renewable Electricity Generation 2016
  - Thermal Management Technology and Market Perspectives in Power Electronics and LEDs 2017

- **BATTERY AND ENERGY MANAGEMENT**
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  - Stationary Storage and Automotive Li-ion Battery Packs 2016
  - Opportunities for Power Electronics in Renewable Electricity Generation 2016

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PATENT ANALYSIS by Knowmade
- Microbattery Patent Landscape Analysis
- Miniaturized Gas Sensors Patent Landscape Analysis
- 3D Cell Culture Technologies Patent Landscape
- Phosphors and QDs for LED Applications Patent Landscape
- TSV Stacked Memory Patent Landscape
- Fan-Out Wafer Level Packaging Patent Landscape Analysis

TEARDOWN & REVERSE COSTING by System Plus Consulting
More than 45 teardowns and reverse costing analysis and cost simulation tools published in 2016.

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