

From Technologies to Market

Status of the Solid-State Lighting Source Industry 2019

Market and Technology
Report 2019

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OBJECTIVES AND KEY FEATURES OF THE REPORTS



The objectives of this report are to provide:

A global examination of SSL source trends

A detailed analysis of SSL source types (visible LED, UV LED, IR LED, EEL, and VCSEL)

An understanding of SSL source markets, applications, industries, and technologies

SSL source players, dynamics, and rankings

SSL source market data in \$M, units, and wafers for 2017 - 2024

Key features:

SSL global market, industry, and technology landscape

Application trends, per source type

Technology trends and development axis, per source type

Industry trends, per source type

Supply chain analysis and market share, per source type

Revenue, unit, and wafer forecasts, per source type

Light function evolution

ABOUT THE AUTHORS

Biographies & contacts



Pars MUKISH

Pars Mukish holds a master degree in Materials Science & Polymers (ITECH - France) and a master degree in Innovation & Technology Management (EM Lyon - France). Since 2015, Pars has taken on responsibility for developing SSL and Display activities activities as Business Unit Manager at Yole Développement (Yole). Pars is part of the Photonics, Sensing & Display division at Yole. Previously, he has worked as Marketing Analyst and Techno-Economic Analyst for several years at the CEA (French Research Center).

Contact: mukish@yole.fr



Pierrick BOULAY

As part of the Photonics, Sensing & Display division at Yole Développement (Yole), Pierrick Boulay works as Market and Technology Analyst in the fields of Solid State Lighting and Lighting Systems to carry out technical, economic and marketing analysis. Pierrick has authored several reports and custom analysis dedicated to topics such as general lighting, automotive lighting, LiDAR, IR LEDs, UV LEDs and VCSELs.

Prior to Yole, Pierrick has worked in several companies where he developed his knowledge on general lighting and on automotive lighting. In the past, he has mostly worked in R&D department for LED lighting applications. Pierrick holds a master degree in Electronics (ESEO – Angers, France).

Contact: boulay@yole.fr



Martin VALLO

Martin Vallo, PhD is serves as a Technology & Market Analyst specialized in solid-state lighting technologies, within the Photonics, Sensing & Display division at Yole Développement (Yole). With 9 years' experience within semiconductor technology, Martin is involved today in the development of technology & market reports as well as the production of custom consulting projects at Yole.

Prior his mission at Yole, he worked at CEA (Grenoble, France), with a mission focused on the epitaxial growth of InGaN/GaN core-shell nanowire LEDs by MOCVD and their characterization for highly flexible photonic devices. Martin graduated from Academy of Sciences, Institute of Electrical Engineering (Slovakia) with an engineering degree in III-nitride semiconductors.

Contact: vallo@yole.fr

COMPANIES CITED IN THIS REPORT

3SPTechnologies, A-Bright, Access Pacific Ltd., Adtech Optics, Advanced Laser Diode Systems (A.L.S.) GmbH (NKT Photonics), Akela Laser Corp., Allwave Lasers, Alpes Lasers, AltaLED, American Bright, AOT, Apex Science & Engineering Corp., Applied Optoelectronics, Arima, Arima Lasers, Bolb, Bridgelux, Bright Solutions, BrightLED, Broadcom, Brolis Semiconductors, BYD, Canadian Photonics Fabrication Centre - Unit of National Research Council of Canada, Citizen Electronic, Clean Technology Leader (CTL), Coherent, Compound Photonics, CREE, CST Global Ltd, Daina, Denselight Semiconductors Pte. Ltd. - Div. of Poet Technologies, DILAS - Part of Coherent, Diode Laser Concepts, Dominant Opto Technologies, eagleyard Photonics GmbH, Eblana Photonics, Edison Opto, Egismos Technology, Electech (ETI), Emcore, Epileds, Epilight Technologies, Epistar, Epitex (Ushio Opto Semiconductors), Epitop, Everlight, Excellence Opto Inc., Fiibercom Ltd, Finisar, FITEL - Furukawa, Flip Chip Opto, Fox Group, FullSun Optotech, FuriElectric (Runlite Technology), Genesis Photonic Inc. (GPI), Gooch & Housego, Hamamatsu, Harvatek, HC Semitek, Helio, High Power Opto, Honglitrionic (HongliZhihui), HPLighting (High Power Lighting), II-VI Laser Enterprise, Iijin Semiconductor, Innolume, Innovative Photonic Solutions, Inolux, InPhenix, Intense Photonics, IPG Photonics, Itswell, JENOPTIK, Jufei Optoelectronics, Kingbright, Kodenshi, Kwality Group, Laserline, LaserMaxDefense, LasersCom, Lasertel (/SELEX Galileo), Lattice Power, LDX Optronics, LED Engin, Inc (Part of Osram), Ledtech, Lextar, LG Innotek, Lighten Corp., Ligitek, LiteOn, Lumens, Lumentum (/Oclaro), Lumex, Lumichip, Lumics, Lumileds, LumiMicro, Lumimodule, Luminus Devices, Luxpia, Masimo Semiconductor, Mason Technologies Corp. (MTC), Mitsubishi Chemical, Mitsubishi Electric, Modulight (/Medical Laser), Mok San Electronics, Monocrom, Mulinsen (MLS), nanoplus, Nationstar, Necsel (/Ushio), Neo Neon, Newport Corp. (now MKS Instruments), Nichia, nLIGHT Corporation, NOLATECH, Norcada Inc, Norlase, Northrop Grumman Cutting Edge Optronics (CEO), Oasis, Oclaro (/Lumentum), Optek Technology (Part of TT Electronics), Optodiode, OPTOENERGY, Optotech, Optoway Technology Inc, OSI Laser Diode, Osram OS, Panasonic Semiconductor Solutions Co., Ltd. (Japan), Paralight, PD-LD, Pegasus Lasersysteme GmbH, Photodigm, Plessey Semiconductor, Powerlightec, Prolight Opto Technology, QD Laser, QPC Lasers, QSI, Quantel (Lumibird), Quantum Light Instruments, Quantum wafer, Redfern Integrated Optics (RIO) (/OptaSense), Refond, Rofin-Sinar Technologies, Inc. (now Coherent), Rohm, Sacher Lasertechnik LLC, Samsung LED, Sanan, Sanken Electric, SemiLEDs, Seminex, Seoul Semiconductor, Sharp, Sheumann Laser Inc, ShineOn, Showa Denko (TS Opto), Silan Microelectronics, SLD Laser, Sony Semiconductor Solutions, Source Photonics, Stanley, Sumitomo Electric, Sunpu-Opto, Tekcore, Thorlabs, Toptica Photonics, Toyoda Gosei, Trumpf, UnikLasers, Union Optronics, Unity Opto, UPEC, Ushio Opto Semiconductors, VCC, Vescent Photonics, Violumas, Vortran Laser Technology, Walsin Lihwa, Wooree LED, World Star Tech, Würth Electronics, Z-Laser Optoelektronik, and more.

SOLID STATE LIGHTING SOURCE - INTRODUCTION

Scope of the report (ie technologies analyzed) (1/2)

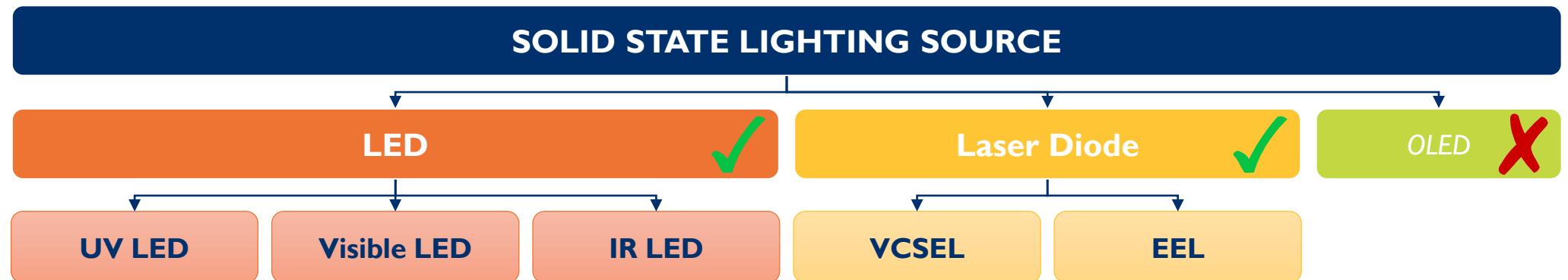
Solid State Lighting (SSL) refers to a type of lighting that uses semiconductor diodes (ie light emitting diodes, laser diodes) or Organic Light Emitting Diodes (OLED) as sources of illumination rather than electrical filaments, plasma (used in arc lamps such as fluorescent lamps), gas (...).

In our report, we will however exclude OLED from the scope of work as such organic devices induce totally different technology, manufacturing process, industry and markets/applications compared to semiconductor diodes.

- Technology/Manufacturing aspects → OLED manufacturing is not based on semiconductor process and require totally different expertise, know-how, manufacturing equipment and materials (...).
- Industry aspects → Consequently, industry and player involved (ie device manufacturers but also equipment/material suppliers...) in OLED are different than for semiconductor diodes, and there is no real overlap nowadays.
- Market/Application aspects → OLED is mostly driven nowadays by display applications (eg mobiles, TVs) which is one key business area for visible LED (ie LCD based displays). However there is a clear trend in this business to switch from LED displays to OLED displays which make LED revenues declining for such applications. In the future, we expect OLED to dominate this market.

➔ **In the end, OLED have synergies with visible LED only and regarding a unique market/application (ie display one)!!!**

In our report, we will use the following segmentation of SSL source, excluding OLED as explained previously:

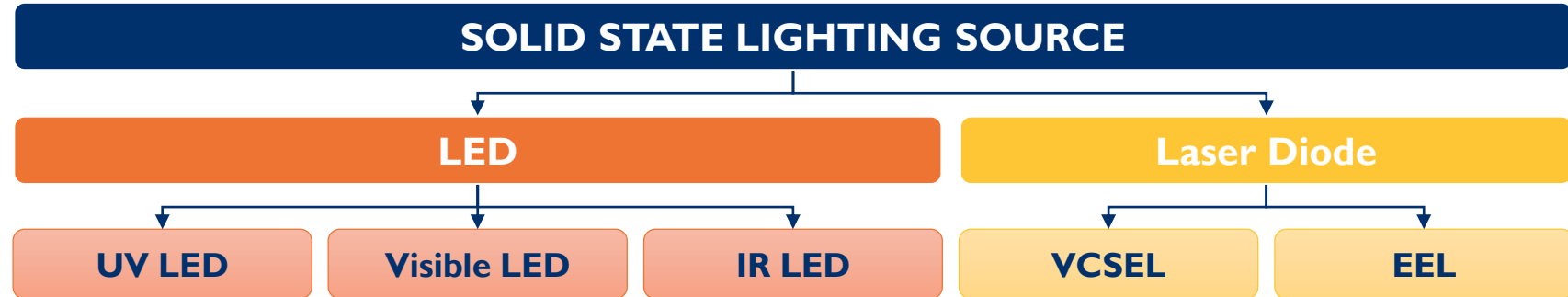


This report focus only on semiconductor-type Solid State Lighting (SSL) source (ie LED and laser diodes).

OLED technology, industry and applications being too specific to be compared with LED and laser diode.

SOLID STATE LIGHTING SOURCE - INTRODUCTION

Scope of the report (ie technologies analyzed) (2/2)



LED will be segmented by category of wavelengths (ie ultraviolet vs. visible vs. infrared) as different industries are involved (even if there is a recent trend to see more and more LED players getting involved in the 3 wavelengths).

For laser diodes, such segmentation provide less value as:

- VCSEL business is nearly fully based on applications using IR light sources.
 - IR VCSEL were driving more than 99% of total VCSEL revenues in 2018.
 - There is no real business for UV or visible VCSEL today as UV/Visible devices are still under development (ie technology not mature yet and mostly at the R&D level) and we don't expect any breakthrough evolution in the next 5 years.
- EEL business is also strongly driven by IR light sources.
 - IR EEL were driving ~81% of total EEL revenues in 2018. We expect this figure to reach ~88% in 2024, highlighting a continuous growth of IR EEL business (ie much more higher growth than for UV or Visible EEL).

Differentiating laser diode technology by device type (ie EEL vs. VCSEL) is also of importance as related industries are quite different even if linked through one key application: optical transceivers (for datacom/telecom applications), which represented the major revenue driver for both type of laser diodes (until 2017 at least - After, emergence of 3D sensing applications has totally changed the business landscape for VCSEL).

- Please note that VCSEL and EEL were not directly competing on optical transceivers application as VCSEL are used for short-distance communication whereas EEL are used for middle-/long-distance communication → It further reinforce the choice to analyze VCSEL and EEL industry separately.

LEDs will be segmented by wavelengths whereas segmentation of laser diodes will be done by device type.

Such choice has been done mostly as related industry are structured this way today.

SOLID STATE LIGHTING SOURCE - MARKET FORECAST

Scope of applications

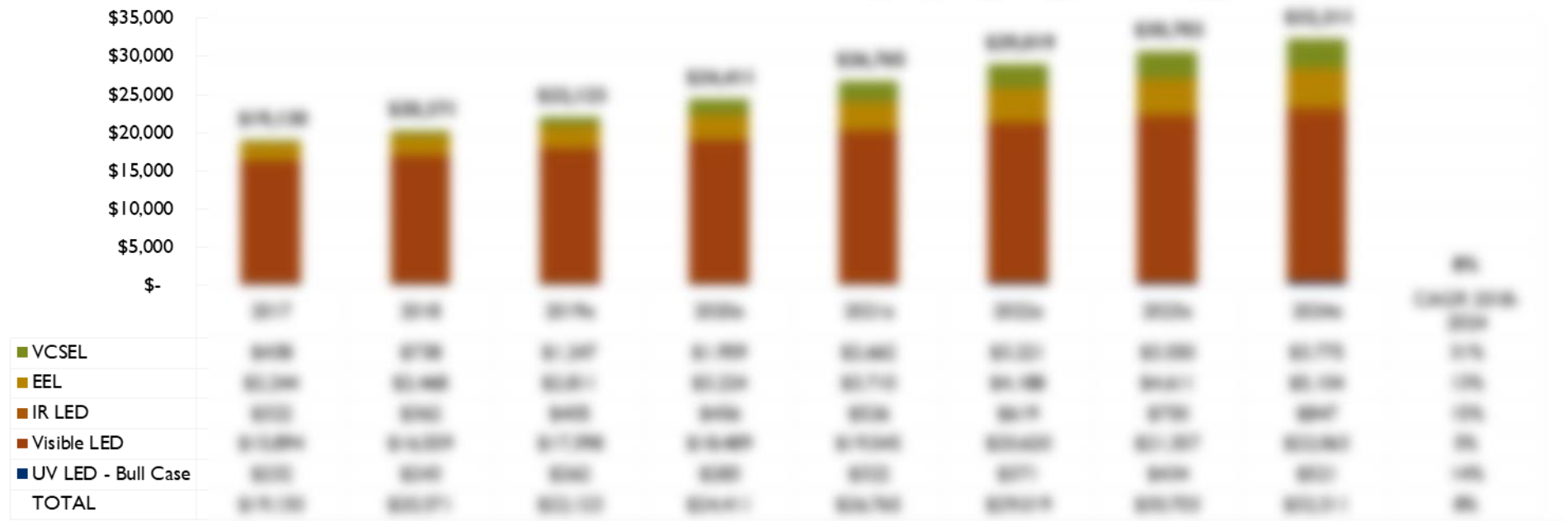
	Mobile & Consumer	Automotive & Transportation	Telecom & Infrastructure	Medical	Industrial	Defense & Aerospace
Visible LED	<ul style="list-style-type: none"> LCD TVs and monitors Notebooks and tablets Mobiles - Display & Flash General lighting systems 	<ul style="list-style-type: none"> Automotive lighting systems 			<ul style="list-style-type: none"> Direct view displays General lighting systems Horticultural lighting systems 	<p><i>Some few applications exist for defense & aerospace segment but are not integrated into our analysis as representing less than 0.1% of SSL source market revenues</i></p>
UV LED	<ul style="list-style-type: none"> Remote controls Proximity sensors Surveillance cameras Eye tracking systems 	<ul style="list-style-type: none"> Rain sensors 			<ul style="list-style-type: none"> Horticultural lighting systems Gas sensors (NDIR) Surveillance cameras Machine vision systems 	
IR LED	<ul style="list-style-type: none"> UV curing systems Disinfection systems 			<ul style="list-style-type: none"> Disinfection systems Analytical instruments Phototherapy systems 	<ul style="list-style-type: none"> UV curing systems Disinfection systems Counterfeit detection systems Photocatalytic purification syst. Analytical instruments 	
VCSEL	<ul style="list-style-type: none"> 3D cameras - Front & Rear Laser rangars - Mobile & Headsets Computer mice 	<ul style="list-style-type: none"> LIDARs 	<ul style="list-style-type: none"> Optical transceivers 		<ul style="list-style-type: none"> Heating systems Laser printers 	
EEL	<ul style="list-style-type: none"> 3D cameras - Rear General lighting systems 	<ul style="list-style-type: none"> LiDARs Automotive lighting systems 	<ul style="list-style-type: none"> Optical transceivers Fiber sensors Telecom instrumentation systems 	<ul style="list-style-type: none"> Medical laser systems Analytical instruments 	<ul style="list-style-type: none"> Material processing systems LiDARs Machine vision systems Analytical instruments 	

Note: Only major applications are listed here - Several other applications exist for each SSL source but their respective market value can be considered as negligible compared to the total market revenue of the SSL source - The one in black are the one involved in multiple SSL source

SOLID STATE LIGHTING SOURCE - MARKET FORECAST

2017-2024 market forecast - Split by source type - Level 2 - Revenue

SSL Source - 2017-2024 market revenue forecast (\$M) - Split by source type - Level 2



Within LED, visible LED represents the bulk of the market revenues.

Within laser diode, EEL are currently the largest market opportunity but VCSEL will rapidly catch up in the future.

- Visible LED represented ~96% of total LED market size in 2018 and this share is likely to remain in the same range in 2024 (ie ~94%).
- Scope of applications in the UV range is much more limited than in the visible space - Even if disinfection/purification applications could really make the UV LED market boom when they will fully materialize (what we don't expect in the next 5 years).
 - Several new (high-value) applications are just emerging in the IR range but VCSELS are likely to catch the maximum of this opportunity.

Regarding laser diode, VCSEL is the technology experiencing the higher growth rate in the next 5 years ($CAGR_{2018-2024} = 31\%$), mostly driven by 3D sensing applications in the smartphone space (ie 3D cameras). On their side, EELs continue their way at a non negligible $CAGR_{2018-2024}$ of 13% and mostly driven by telecom applications (ie optical transceivers).

SOLID STATE LIGHTING SOURCE - MARKET FORECAST

2017-2024 market forecast - Telecom & Infrastructure - Split by source type

Telecom & Infrastructure is a quite specific segment in which laser diodes have an opportunity related to optical communication.

Telecom & Infrastructure represent the historical segment of laser diodes.

First high volume applications were found in this segment (eg optical transceivers).

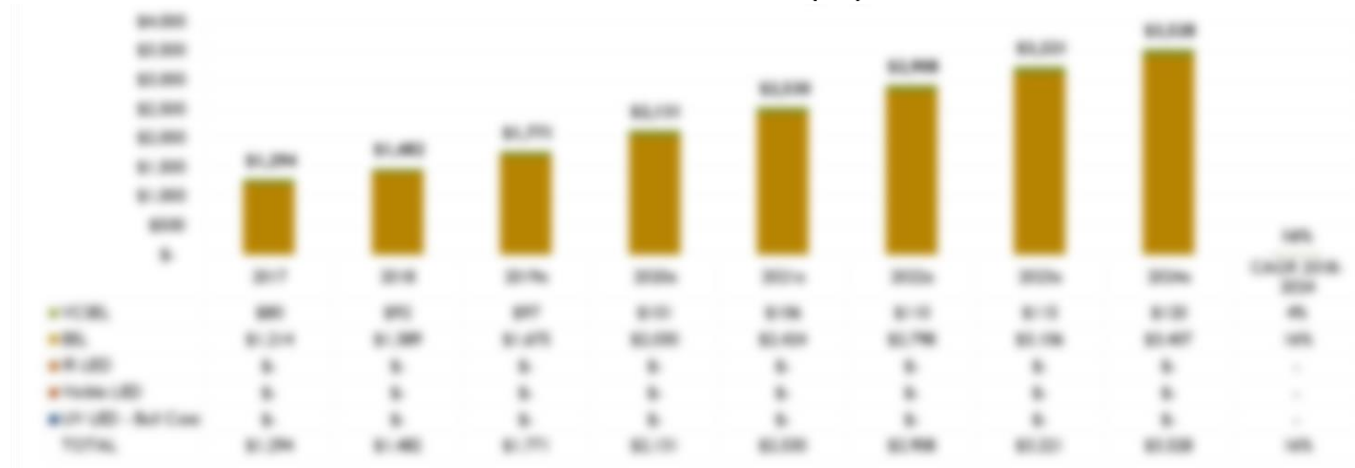
Both EEL and VCSEL are used but not directly in a competitive way:

- VCSEL for short distance communication range (ie datacom).
- EEL for long-distance communication range (ie telecom).

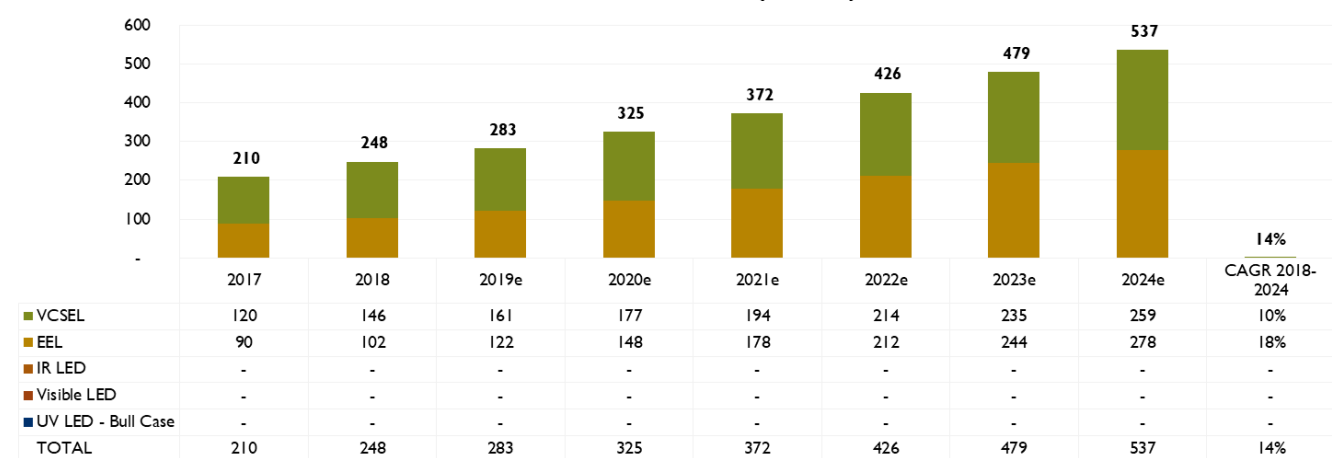
The associated revenue is however in favor of EEL as telecom business is much more bigger than datacom one.

Regarding LED, there are not really used in such segment due to intrinsic limitations in terms of light shaping features (ie lambertian emission from all facets + incoherent light)

SSL Source - 2017-2024 market revenue forecast (\$M) - Telecom & Infrastructure



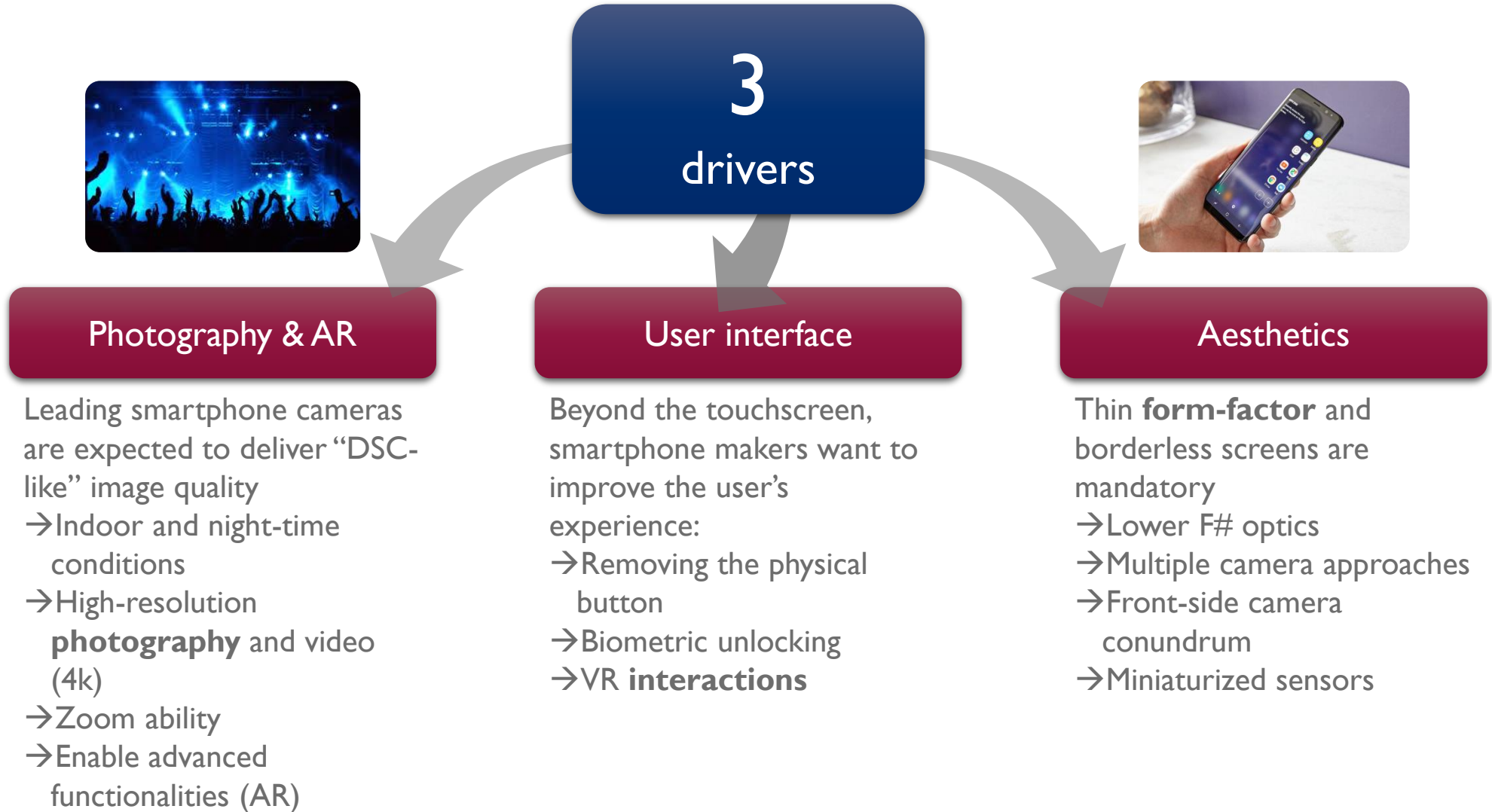
SSL Source - 2017-2024 market volume forecast (Munits) - Telecom & Infrastructure



SOLID STATE LIGHTING SOURCE - MARKET SEGMENT TRENDS

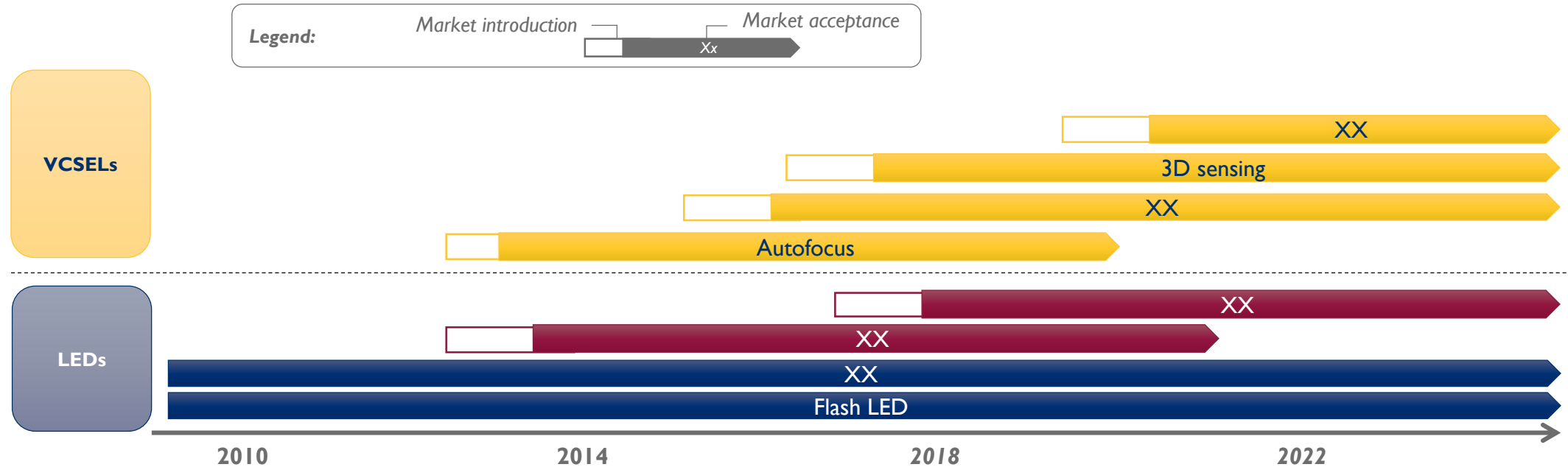
Mobile - Market driver

Smartphone (ie Mobile & Consumer) drivers are pulling in different directions.



SOLID STATE LIGHTING SOURCE - MARKET SEGMENT TRENDS

Mobile - Roadmap - Use of SSL sources in smartphone applications



LEDs are used in XX applications while VCSELs are implemented in XX applications.

Functionalities using IR light sources have been implemented in smartphones for a number of years.

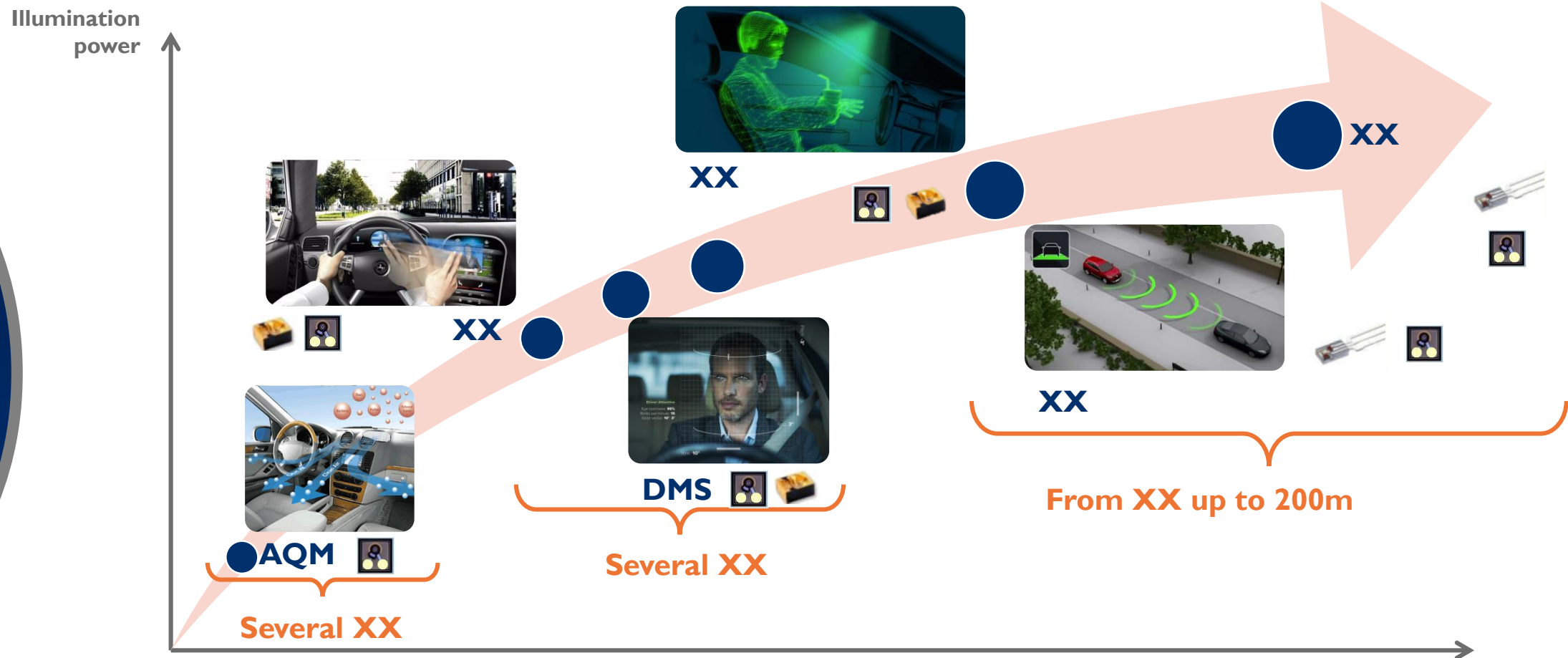
XX can use either LEDs or VCSELs. While VCSELs can enable new functionalities in XX, many smartphone manufacturers continue to use XX with LEDs as they have a single purpose and are very cheap.

Applications are no longer basic as is the case with XX which use a XX combined with XX. **New applications are more complex, using XX and new light sources like VCSELs.**

SOLID STATE LIGHTING SOURCE - MARKET SEGMENT TRENDS

Automotive - Light sources for sensing applications

Following the application, the target distance can vary from a few mm up to 200m. Therefore, the type of light source has to be carefully chosen.



Legend:

EEL



LED



VCSEL

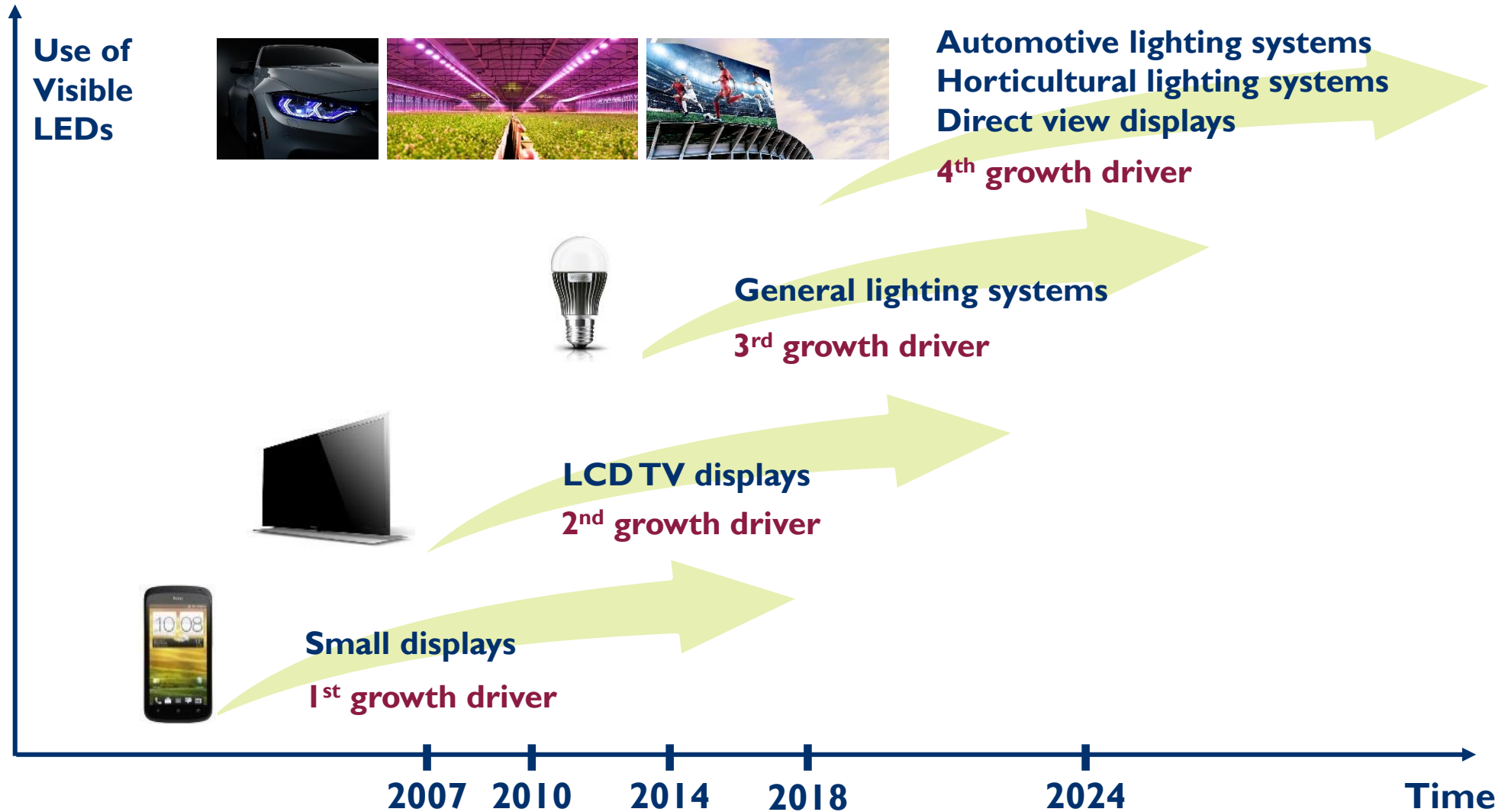


- All of these applications have similar wavelengths between XXnm and XXnm except for XX that can use 1550nm for eye safety reasons.
- XX sources are expected to be replaced by XX.

VISIBLE LED - MARKET TRENDS

Market drivers

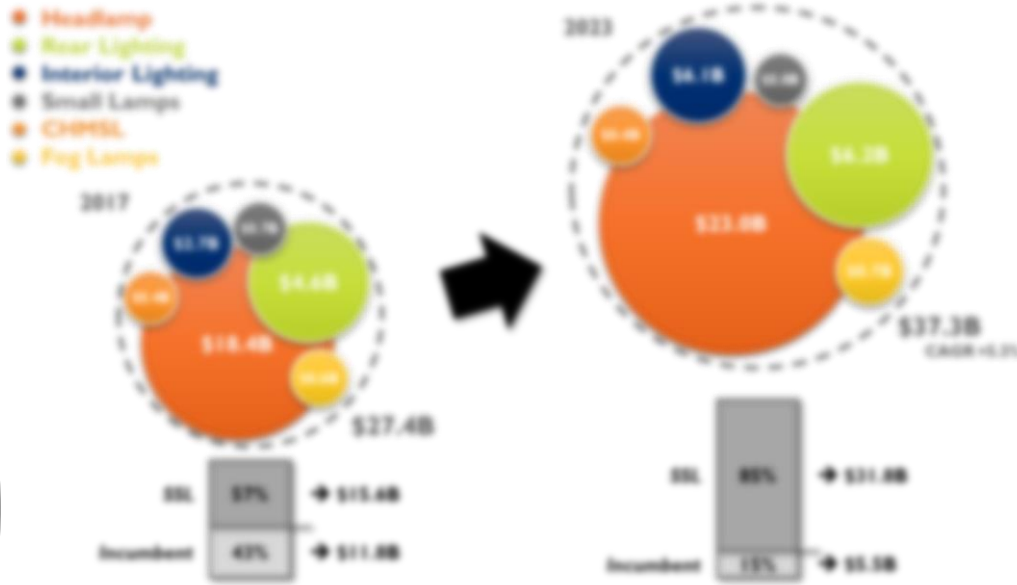
IR LEDs were used in basic applications at first. Since then, the complexity keeps increasing with more signal processing.



VISIBLE LED - APPLICATION LANDSCAPE

Analysis of key applications - Automotive lighting systems

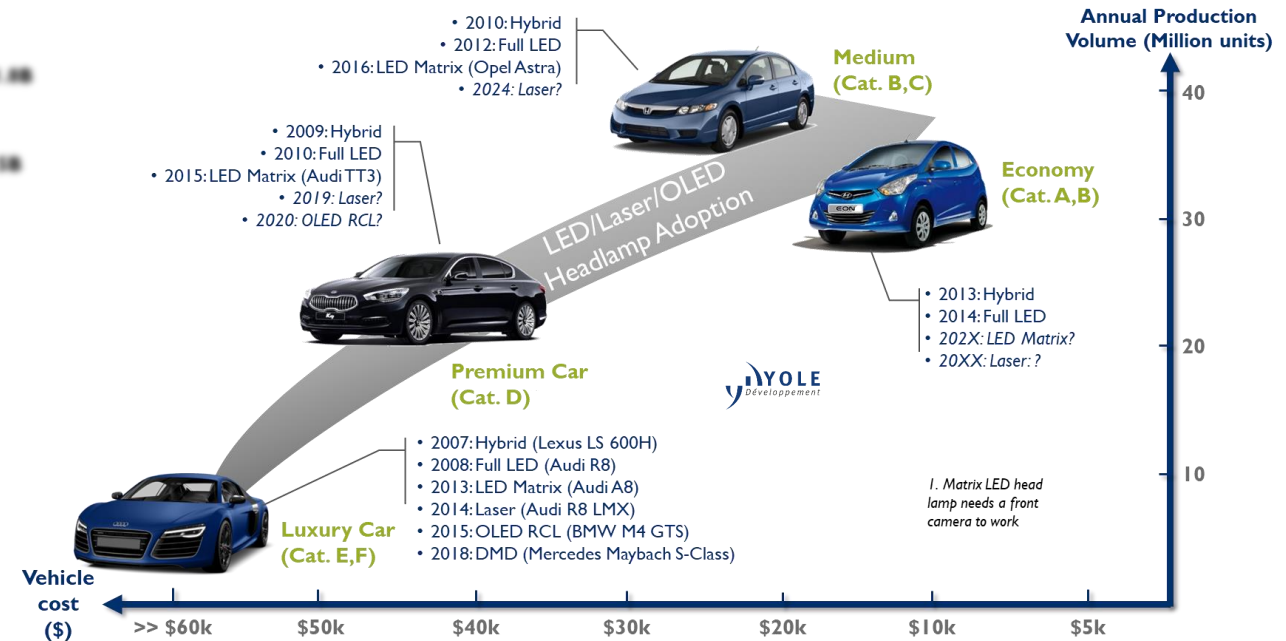
Increased penetration rate of LED technology and development of advanced automotive lighting systems is driving the automotive lighting market.



Automotive Lighting Systems Market Trends

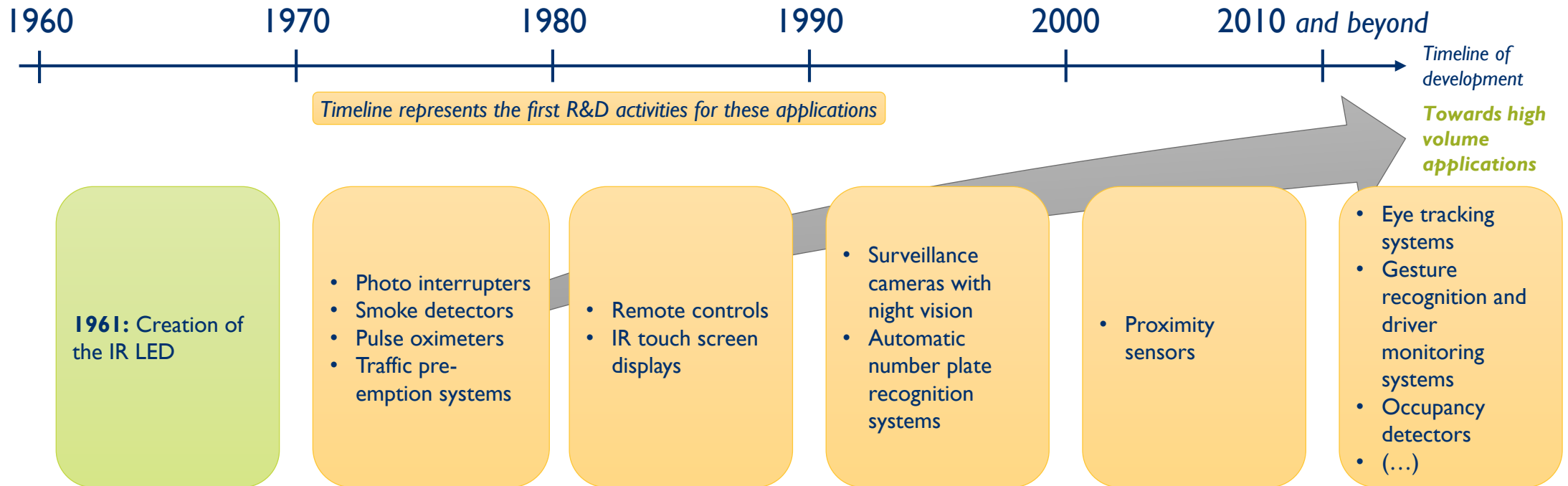
New technologies and features will make automotive lighting systems a \$37.3B market by 2023.

Progression of Automotive Lighting Technologies
 LED technologies are progressing from options to standard on luxury, premium and medium cars, before becoming options on economy cars.



IR LED - INTRODUCTION

Historical perspective



The first applications to be developed were simple, combining an IR LED and a photodetector to produce an on or off output signal as in photo interrupters or smoke detectors.

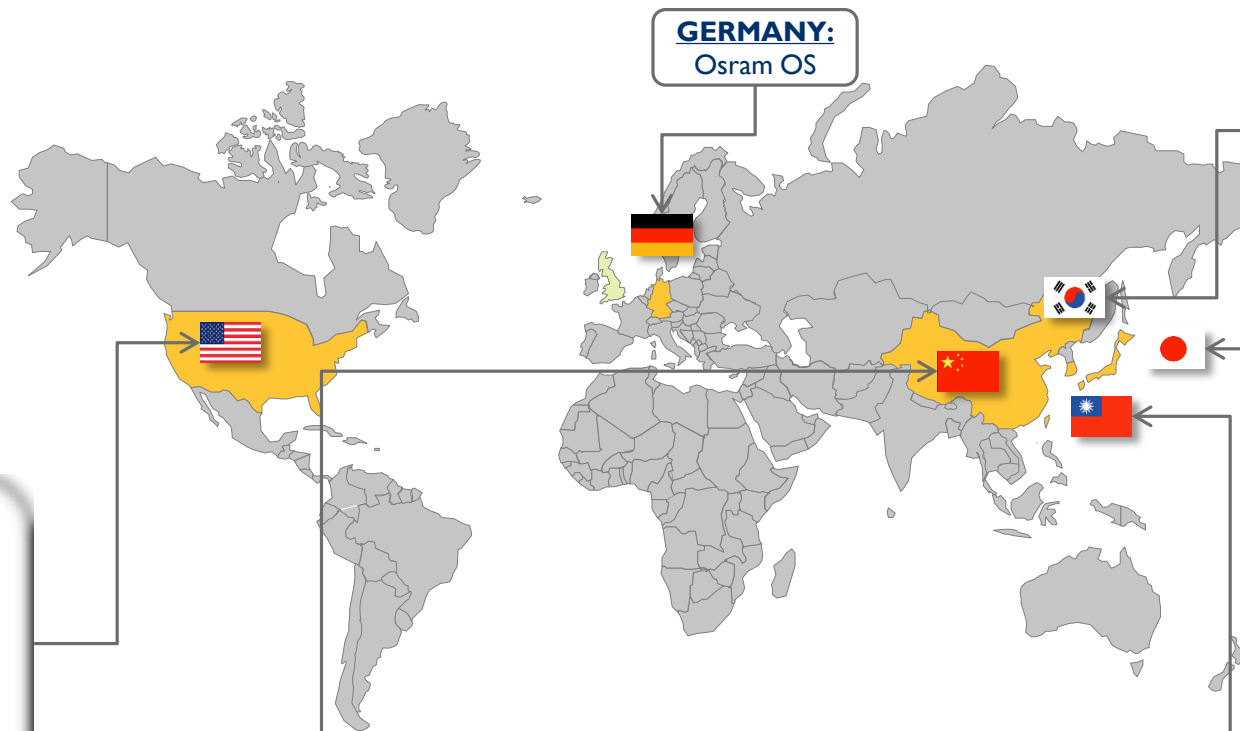
The **first big consumer application using IR LEDs was the remote control** in the 1980s, **followed by surveillance cameras with night vision** in the 1990s following the development of image sensors.

Nowadays, the **development of new, smart functionalities** in smartphone, medical and automotive applications and **development of breakthrough devices and functions** such as wearables, miniaturized systems and virtual reality ones is **driving IR LEDs towards new applications**. Those are **mostly related to sensing and imaging features**.

IR LED - INDUSTRIAL LANDSCAPE

Map of players - Package level

More than XX manufacturers are involved in IR LEDs. Most of them are located in China and Taiwan.

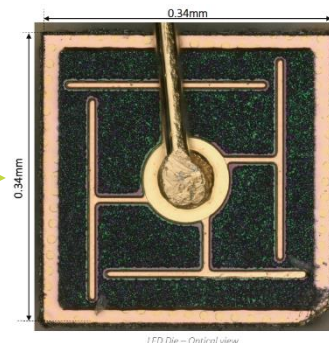
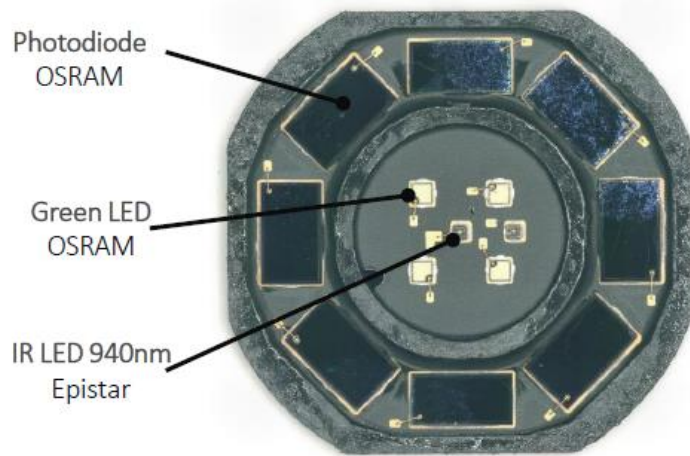


SOUTH KOREA

- Itswell
- Mok San Electronics
- Samsung (for internal use)
- LG Innotek (for internal use)

Cost aspects - IR LED in the Apple watch 4 (Source: System Plus Consulting)

Contrary to visible LED, XX still represents a strong cost factor in IR LED manufacturing at the moment. Main reason is that manufacturing process and materials are different (and less mastered).



- Basic IR InGaAlP LED chips are typically 20 - 30% more expensive than blue GaN-based chips.
- For flip-chip (FC), the gap increases dramatically: up to 3 - 4x more expensive than blue FC. However, this gap has slimmed down from 20 - 30x only a few years back as there is more demand, and so development) for such devices



According to yield variations, the die ASP is estimated between \$XX and \$XX



Analysis of IR LED found in the Apple Watch 4
Source: System Plus Consulting

UV LED - INDUSTRIAL LANDSCAPE

Ecosystem analysis - Supply chain trends

In UVA, the bulk of players are only packagers while in UVB/C, the bulk of players are vertically integrated to master the technology developments.



VCSEL - APPLICATION LANDSCAPE

Analysis of key applications - 3D cameras - Roadmap - Rear

2015



LG G4

Rear camera
**direct time of flight
SPAD**
Range: few meters

Used for autofocus



2018



Oppo RX17 Pro

Rear 3D camera
indirect time of flight
Range: few meters

Used for XX



+

Used for XX

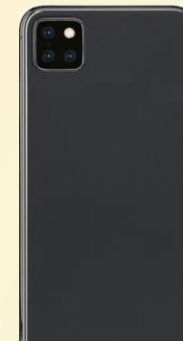


20XX



Rear 3D camera
**direct time of flight
SPAD arrays**
Range: up to 5-6m

20XX



Rear 3D camera
direct time of flight with SPAD array
Range: up to 10m?

Still emerging rear side applications are expected to evolve from photography to augmented reality.

VCSEL - TECHNOLOGY LANDSCAPE

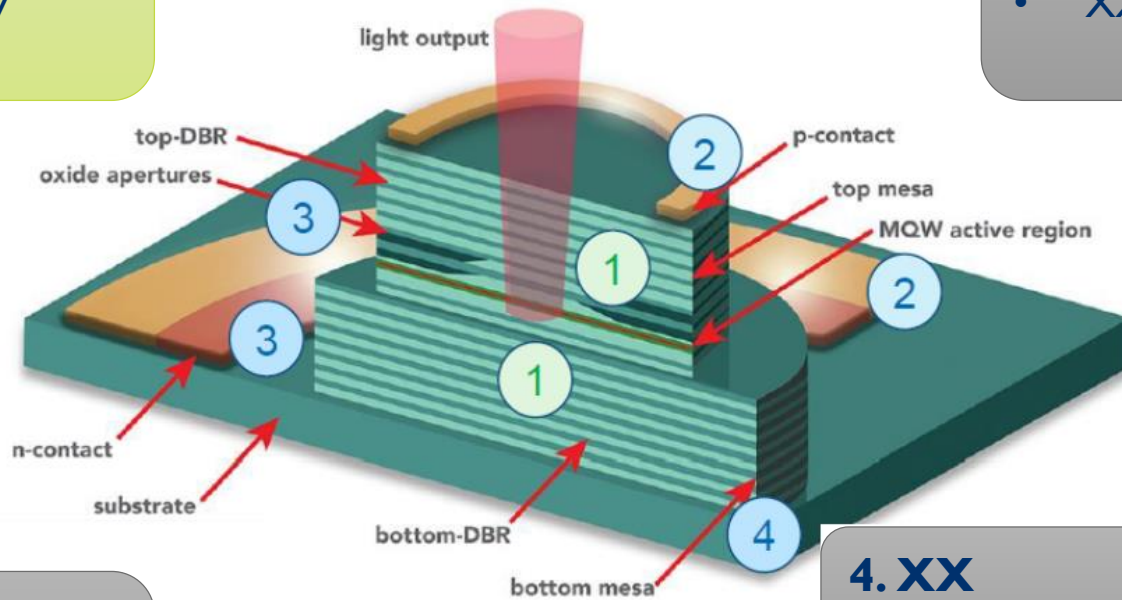
Manufacturing process - Chip manufacturing - Critical steps

1. Epitaxy

- Thickness uniformity
- Compositional uniformity
- Repeatability

2. XX

- XX



Representative VCSEL cross section

3. XX

- XX

4. XX

- Defectivity

LEGEND:

XX

XX

Overview of critical steps in VCSEL manufacturing

Source: Veeco

Application vs. Function

Data transfer (ie communication)

- Optical transceivers

Scanning

- Laser printers

Encoding

- Optical storage systems

Backlighting & projection (ie displaying)

- Displays - TVs & Cinemas

Emission (ie lighting)

- General lighting systems
- Automotive lighting systems

Material processing

- Industrial material processing systems
- Medical laser systems

Detection & measurement

Sensing

- LiDARs
- Pulse oximeters
- Analytical instruments
- Fiber sensors

Imaging

- Machine vision systems
- OCT systems
- 3D cameras
- UV inspection systems

EEL - INDUSTRIAL LANDSCAPE

Trends - Rise of Chinese laser industry?

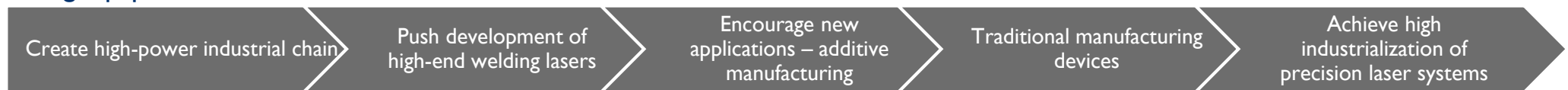
Chinese laser industry has overcome technical challenges in recent three years thus has become self contained. Local Chinese producers have developed 10, 12 and 20 kW fiber lasers successively since 2013, realizing import substitution in a progressive way.

The Chinese industrial laser market was up 12% from a year ago and accounting for 17% of the global market. It is predicted to sustain a growth rate during 2019-2023 despite of US tariffs.

Competitive landscape → Global top 5 manufacturers held a combined market share of over 80% in 2017 (Trumpf XX% , IPG XX%, Chinese largest player **Han's Laser XX%**).

China will keep developing the laser systems: new core lasers, high-end laser manufacturing equipment, and laser machining.

Hubei's laser industry chain forecasts to reach value of 100 billion yuan (\$15 billion) with an average growth rate 25%. The province plans to create special industrial cluster that will be a world first in fractionized field → leading enterprises will improve production of laser cutting equipment:

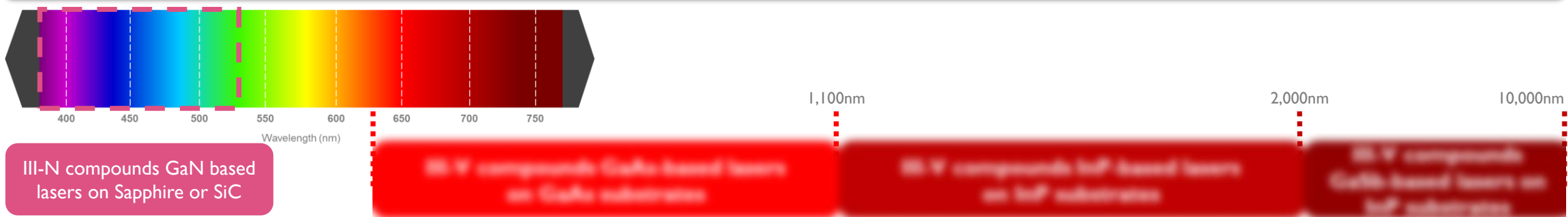


China now has numerous laser system manufacturers and research institutions with powerful technical resources. Moreover, the laser ecosystem is completed by application clients such as the large state-owned manufacturing enterprises.

EEL - TECHNOLOGY LANDSCAPE

Segmentation - Overview

Semiconductor lasers types



EEL chip designs

Fabry Péro (FP) lasers

Distributed Bragg Reflector (DBR) lasers

Distributed Feedback (DFB) lasers

Broad Area Laser Diode (BALD)

Semiconductor lasers are comprised of a large group of binary, ternary, and quaternary elements from Groups III -VI of the periodic table. These lasers can have emission ranges from the UV (<400 nm), blue (~400 nm) to the IR by combining elements from Groups III and V or Groups IV and VI, respectively.

This large emission range combined with the small device footprint, low operating current, low operating cost, and high efficiency make semiconductor lasers one of the most important and widely used classes of lasers in use today.

Fabry Péro (FP) lasers	Distributed Bragg Reflector (DBR) lasers	Distributed Feedback (DFB) lasers	Broad Area Laser Diode (BALD)
Vertical lasers	Directly Modulated Lasers (DML)	Double Clamped Modulated Lasers (DCML)	Double Bars
	External Modulated Lasers (EML)	Integrated Laser with External Modulator (ILEM)	Double Clamped Modulated Lasers (DCML)
	Quantum Cascade Lasers (QCL)		Non-clamped Double Lasers (NCLD)



Yole Développement

VCSELs – Market and Technology Trends 2019



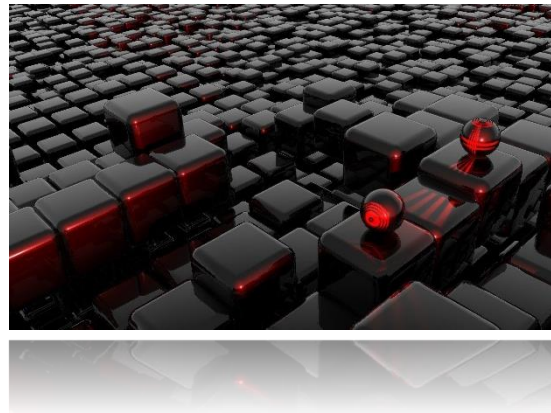
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VCSEL in Smartphone – Comparison 2019



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www.systemplus.fr

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STATUS OF THE SOLID-STATE LIGHTING SOURCE INDUSTRY 2019

Market & Technology Report - July 2019

From lighting to sensing: a new growth era for the solid-state lighting industry.

REPORT KEY FEATURES

- SSL global market, industry, and technology landscape
- Per source type:
 - Application trends
 - Technology trends and development axis
 - Industry trends
 - Supply chain analysis and market share
 - Revenue, unit, and wafer forecasts
- Light function evolution

REPORT OBJECTIVES

The report will provide:

- A global examination of SSL source trends
- A detailed analysis of SSL source types (visible LED, UV LED, IR LED, EEL, and VCSEL)
- An understanding of SSL source markets, applications, industries, and technologies
- SSL source players, dynamics, and rankings
- SSL source market data in \$M, units, and wafers for 2018 - 2024

SOLID-STATE LIGHTING SOURCE - A BUSINESS OPPORTUNITY OF \$32B IN 2024

Solid-state lighting (SSL) sources aren't new technologies. In fact, they've existed since the 1960s. However, only in the last 25 years have they started appearing in high-volume applications.

Laser diode (LD) found its sweet spot in the 1990s as a light source for optical transceivers used in datacom (i.e. vertical cavity surface-emitting laser (VCSEL)) and telecom (i.e. edge-emitting laser (EEL)) applications. Further refinement, coupled with the internet's boom, drove the LD market forward to a point where each technology has now followed its own path.

EEL, driven by the increased use of lasers in different industries, soon found growth opportunities in areas like material processing and optical storage. VCSEL took more time to find its strong growth drivers, but the smartphone boom created a window of opportunity that allowed VCSEL to find its killer application: 3D sensing.

In 2018, LD represented a market opportunity of \$3.2B. This figure is likely to reach \$8.9B in 2024, at a CAGR₂₀₁₈₋₂₀₂₄ of 18%.

Regarding light-emitting diode (LED), it found its first high-volume applications in the 2000s, mostly in the visible LED field: automotive lighting, signs, traffic signals, and the like. Mobile phones were the next key segment, followed by TV LCD backlights and general lighting.

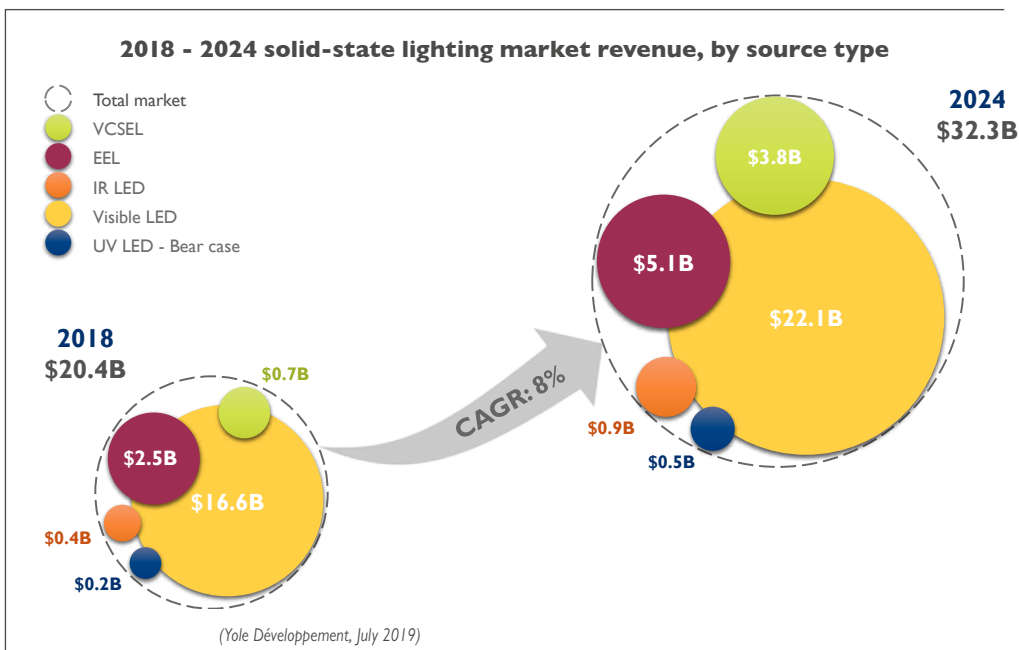
LED growth was non-linear though: periods of recession were followed by waves of new applications and growth, followed by periods of oversupply that depressed prices, etc. This uneven growth resulted in a depressed environment, leading the industry to seek niche/specialized applications in order to reap higher margins and diversify activities towards non-visible LED (i.e. ultraviolet (UV) and infrared (IR)).

In 2018, LED represented a market opportunity of \$17.2B. This figure is likely to reach \$23.4B in 2024, at a CAGR₂₀₁₈₋₂₀₂₄ of 5%.

In this context, the SSL source industry is at a crossroads between:

- An LED industry that has reached a critical size, but is now mature and lacks strong market dynamics (except potential upsides, i.e. microLED displays)
- An LD industry that is booming but still emerging and proliferating, in terms of application/technology landscape

Yole Développement estimates therefore that the overall SSL source market will grow from \$20.4B in 2018 to \$32.3B in 2024, at a CAGR₂₀₁₈₋₂₀₂₄ of 8%. Such growth will be driven mostly by LED technologies. However, related market share will decline from ~84% in 2018 to ~73% in 2024, reflecting different market/application dynamics and a transition towards LD technologies.



GENERAL LIGHTING IS MATURING. WHAT'S NEXT?

LED revenue will continue to thrive on visible applications over the next five years, with general lighting holding the majority (~45% of the total "LED opportunity"). However, such an application has already reached a certain degree of maturity, and thus related LED devices can be considered as commodities - leading to a high-volume/low-margin market.

Automotive lighting and direct-view displays are other booming LED applications. These will become critical for the industry's survival, since most other applications can be considered as declining or "flat" (i.e. LCD backlights). The one exception is horticultural lighting, which is still emerging.

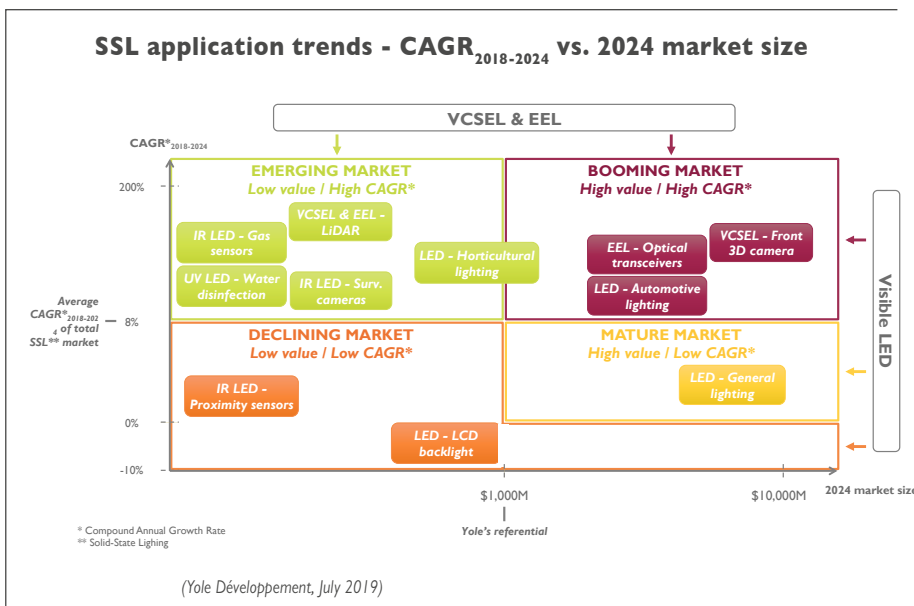
A large part of the LED industry also has a foothold in the non-visible LED market, with UV and IR LEDs highlighting several high-potential applications (i.e. gas sensing and water disinfection). But these are still emerging, and will not fully materialize in the next five years.

On the other hand, the LD industry is booming. Several applications are rising and plenty of others are emerging or in development.

VCSEL, driven by the integration of front 3D cameras in smartphones, will likely see a 5x market revenue increase from 2018 - 2024. And this is just the beginning, with smartphone rear 3D cameras and LiDAR likely next in line.

EEL will experience strong but much steadier growth during the same period (i.e. only a 2x revenue increase), driven mostly by optical transceivers and the increased development of telecom infrastructure (around 55% - 65% of EEL market opportunity). Here also there are a large number of applications that could further boom in the future - for example, LiDAR and sensors.

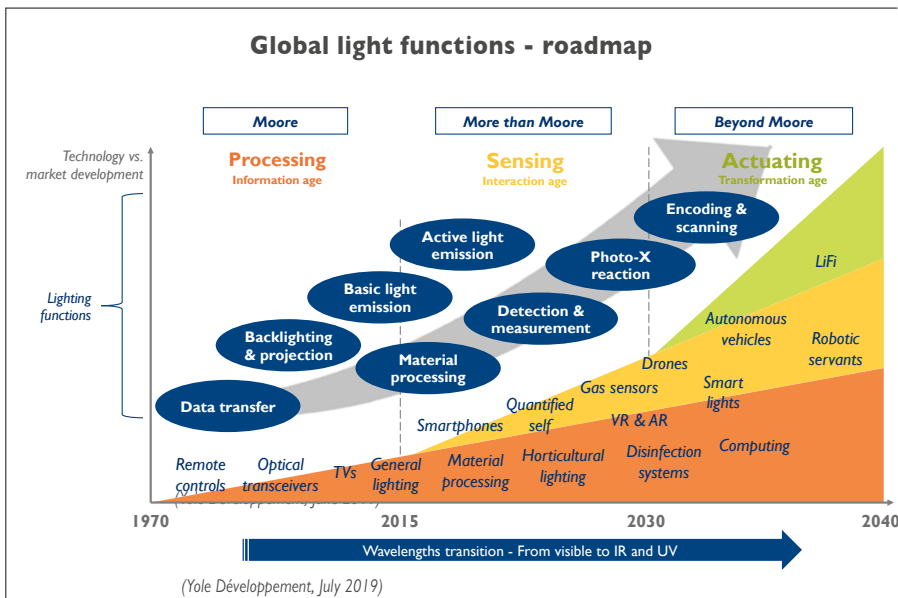
In this context, it is likely that the visible LED industry will further consolidate in the future as markets reach maturity. Such a trend will directly impact other SSL source industries, since several visible LED players might "forage new lands" in order to survive.



WE ARE JUST SCRATCHING THE SURFACE OF LIGHT SCIENCE

The visible SSL market is driven by the best-established, most common functions of light: "basic" lighting (i.e. general lighting) and backlighting (i.e. display). Visible SSL is a replacement market (specifically, replacing old light sources with SSL ones) that will quickly

reach saturation. The only upside will be related to the development of breakthrough SSL sources (i.e. microLED) and applications/systems (LiFi, smart lighting, etc.).



Visible lighting is therefore less and less at the heart of the SSL industry, while IR/UV lighting is experiencing increased interest. Indeed, SSL development has allowed the industry to better understand the science behind light and investigate lighting functions related to UV and IR wavelengths. Typically, UV light provides functions like photopolymerization (i.e. phototherapy) and photodisruption (i.e. water disinfection). When mixed with a miniaturized lighting source, these functionalities can usher in a completely new range of applications, including portable water purifiers.

Such trends are emerging today with IR lighting, driven mostly by detection and measurement functions (i.e. sensing & imaging) for mobile/consumer and automotive/transportation. Smartphones integrating face-recognition features, and automobiles featuring driver-monitoring systems, are just two examples of what is possible with a non-visible SSL source.

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AUTHORS

Pars Mukish holds a master degree in Materials Science & Polymers (ITECH - France) and a master degree in Innovation & Technology Management (EM Lyon - France). Since 2015, Pars has taken on responsibility for developing SSL and Display activities as Business Unit Manager at Yole Développement (Yole). Pars is part of the Photonics, Sensing & Display division at Yole. Previously, he has worked as Marketing Analyst and Techno-Economic Analyst for several years at the CEA (French Research Center).



As part of the Photonics, Sensing & Display division at Yole Développement (Yole), **Pierrick Boulay** works as Market and Technology Analyst in the fields of Solid State Lighting and Lighting Systems to carry out technical, economic and marketing analysis. Pierrick has authored several reports and custom analysis dedicated to topics such as general lighting, automotive lighting, LiDAR, IR LEDs, UV LEDs and VCSELs. Prior to Yole, Pierrick has worked in several companies where he developed his knowledge on general lighting and on automotive lighting. In the past, he has mostly worked in R&D department for LED lighting applications. Pierrick holds a master degree in Electronics (ESEO – Angers, France).



Martin Vallo, PhD, serves as a Technology & Market Analyst specialized in solid-state lighting technologies, within the Photonics, Sensing & Display division at Yole Développement (Yole). With 9 years' experience within semiconductor technology, Martin is involved today in the development of technology & market reports as well as the production of custom consulting projects at Yole. Prior his mission at Yole, he worked at CEA (Grenoble, France), with a mission focused on the epitaxial growth of InGaN/GaN core-shell nanowire LEDs by MOCVD and their characterization for highly flexible photonic devices. Martin graduated from Academy of Sciences, Institute of Electrical Engineering (Slovakia) with an engineering degree in III-nitride semiconductors.

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CONTACTS

For more information about :

- Consulting & Financial Services: Jean-Christophe Eloy (eloy@yole.fr)
- Reports & Monitors: David Jourdan (jourdan@yole.fr) & Fayçal Khamassi (khamassi@yole.fr)
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4.8 The Seller does not make any warranties, express or implied, including, without limitation, those of sale ability and fitness for a particular purpose, with respect to the Products. Although the Seller shall take reasonable steps to screen Products for infection of viruses, worms, Trojan horses or other codes containing contaminating or destructive properties before making the Products available, the Seller cannot guarantee that any Product will be free from infection.

5. FORCE MAJEURE

The Seller shall not be liable for any delay in performance directly or indirectly caused by or resulting from acts of nature, fire, flood, accident, riot, war, government intervention, embargoes, strikes, labour difficulties, equipment failure, late deliveries by suppliers or other difficulties which are beyond the control, and not the fault of the Seller.

6. PROTECTION OF THE SELLER'S IPR

- 6.1 All the IPR attached to the Products are and remain the property of the Seller and are protected under French and international copyright law and conventions.
- 6.2 The Buyer agreed not to disclose, copy, reproduce, redistribute, resell or publish the Product, or any part of it to any other party other than employees of its company (only in the country of the primary user). The Buyer shall have the right to use the Products solely for its own internal information purposes. In particular, the Buyer shall therefore not use the Product for purposes such as:
 - Information storage and retrieval systems;
 - Recordings and re-transmittals over any network (including any local area network);
 - Use in any timesharing, service bureau, bulletin board or similar arrangement or public display;
 - Posting any Product to any other online service (including bulletin boards or the Internet);
 - Licensing, leasing, selling, offering for sale or assigning the Product.
- 6.3 If the Buyer would like to use data coming from the Products for presentations, press announcements and any other projects, the Buyer needs to contact Yole Développement's Public Relations Director (info@yole.fr) to get an official authorization and verify data are up to date. In return the Seller will make sure to provide up-to-date data under a suitable public format.
- 6.4 The Buyer shall be solely responsible towards the Seller of all infringements of this obligation, whether this infringement comes from its employees or any person to whom the Buyer has sent the Products and shall personally take care of any related proceedings, and the Buyer shall bear related financial consequences in their entirety.
- 6.5 The Buyer shall define within its company a contact point for the needs of the contract. This person will be the recipient of each new report. This person shall also be responsible for respect of the copyrights and will guaranty that the Products are not disseminated out of the company. In the context of Bundle and Annual Subscriptions, the contact person shall decide who within the Buyer, shall be entitled to receive the protected link that will allow the Buyer to access the Products.
- 6.6 Please note that whether in Bundles or Annual Subscription, all unselected reports will be cancelled and lost after the 12 month validity period of the contract.
- 6.7 As a matter of fact the investor of a company, external consultants, the joint venture done with a third party, and so on cannot access the report and should pay a full license price.

7. TERMINATION

- 7.1 If the Buyer cancels the order in whole or in part or postpones the date of mailing, the Buyer shall indemnify the Seller for the entire costs that have been incurred as at the date of notification by the Buyer of such delay or cancellation. This may also apply for any other direct or indirect consequential loss that may be borne by the Seller, following this decision.
- 7.2 In the event of breach by one Party under these conditions or the order, the non-breaching Party may send a notification to the other by recorded delivery letter upon which, after a period of thirty (30) days without solving the problem, the non-breaching Party shall be entitled to terminate all the pending orders, without being liable for any compensation.

8. MISCELLANEOUS

All the provisions of these Terms and Conditions are for the benefit of the Seller itself, but also for its licensors, employees and agents. Each of them is entitled to assert and enforce those provisions against the Buyer. Any notices under these Terms and Conditions shall be given in writing. They shall be effective upon receipt by the other Party. The Seller may, from time to time, update these Terms and Conditions and the Buyer, is deemed to have accepted the latest version of these terms and conditions, provided they have been communicated to him in due time.

9. GOVERNING LAW AND JURISDICTION

- 9.1 Any dispute arising out or linked to these Terms and Conditions or to any contract/orders entered into in application of these Terms and Conditions shall be settled by the French Commercial Courts of Lyon, which shall have exclusive jurisdiction upon such issues.
- 9.2 French law shall govern the relation between the Buyer and the Seller, in accordance with these Terms and Conditions.

Yole Développement

From Technologies to Market

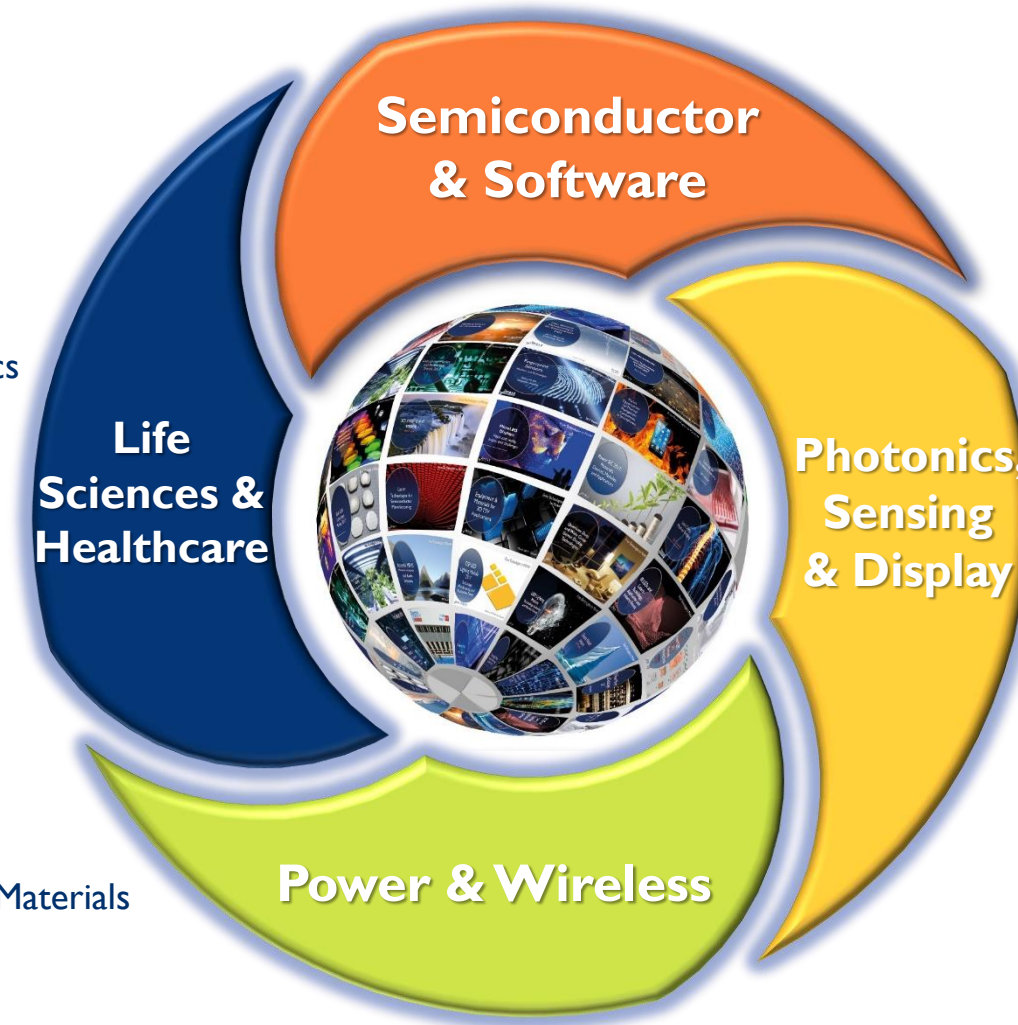


Life Sciences & Healthcare

- 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



○ 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)

www.yole.fr



○ Syndicated reports

- Market & technology reports
- Patent investigation and patent infringement risk analysis
- Teardowns & reverse costing analysis
- Cost simulation tool

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



○ Media

- i-Micronews.com website
- i-Micronews e-newsletter
- Communication & webcast services
- Events: TechDays, forums,...

www.i-Micronews.com



Yole Group of Companies



Market, technology and strategy consulting

www.yole.fr



Manufacturing costs analysis
Teardown and reverse engineering
Cost simulation tools

www.systemplus.fr



IP analysis
Patent assessment

www.knowmade.fr



Design and characterization of innovative optical systems

www.piseo.fr



Innovation and business maker

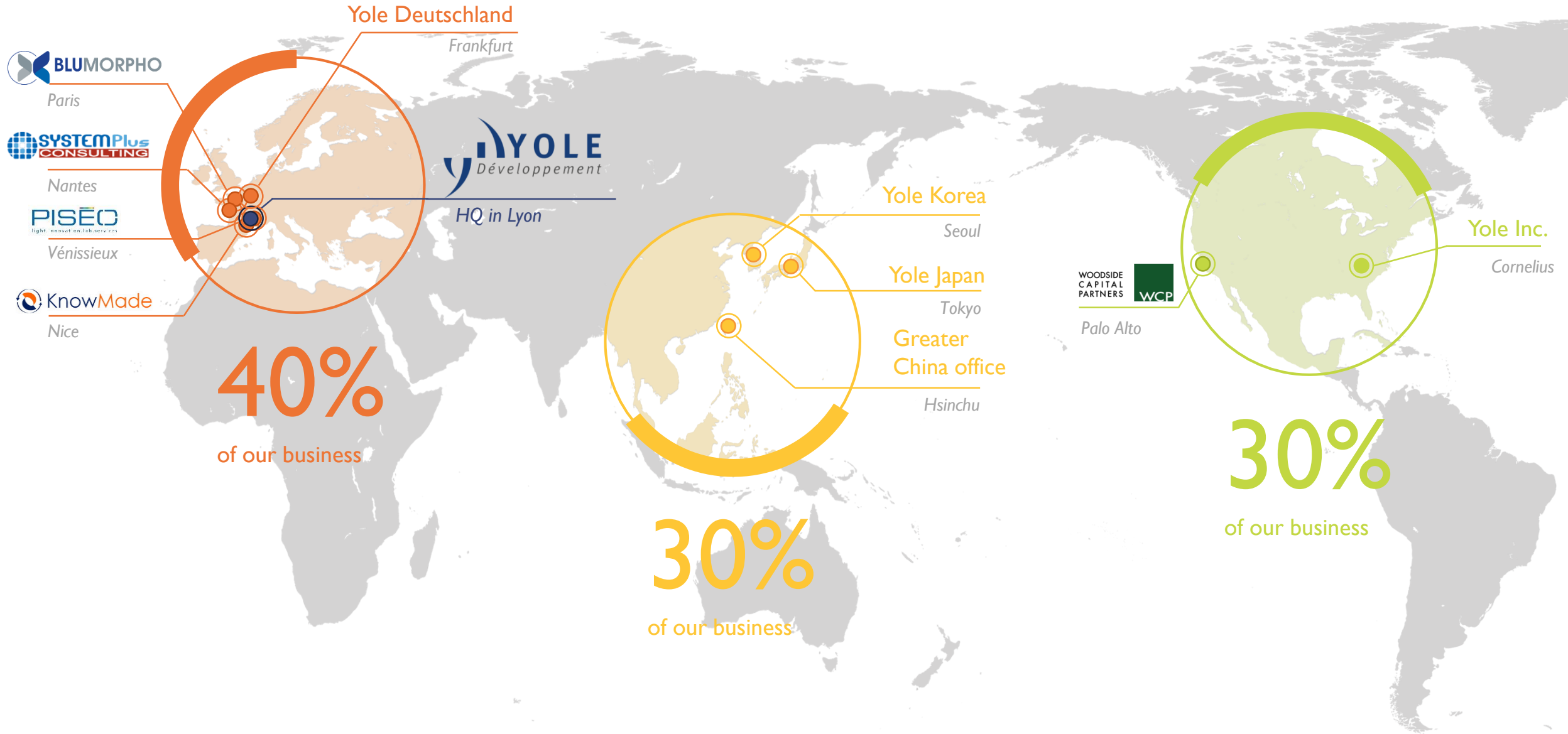
www.bmorpho.com



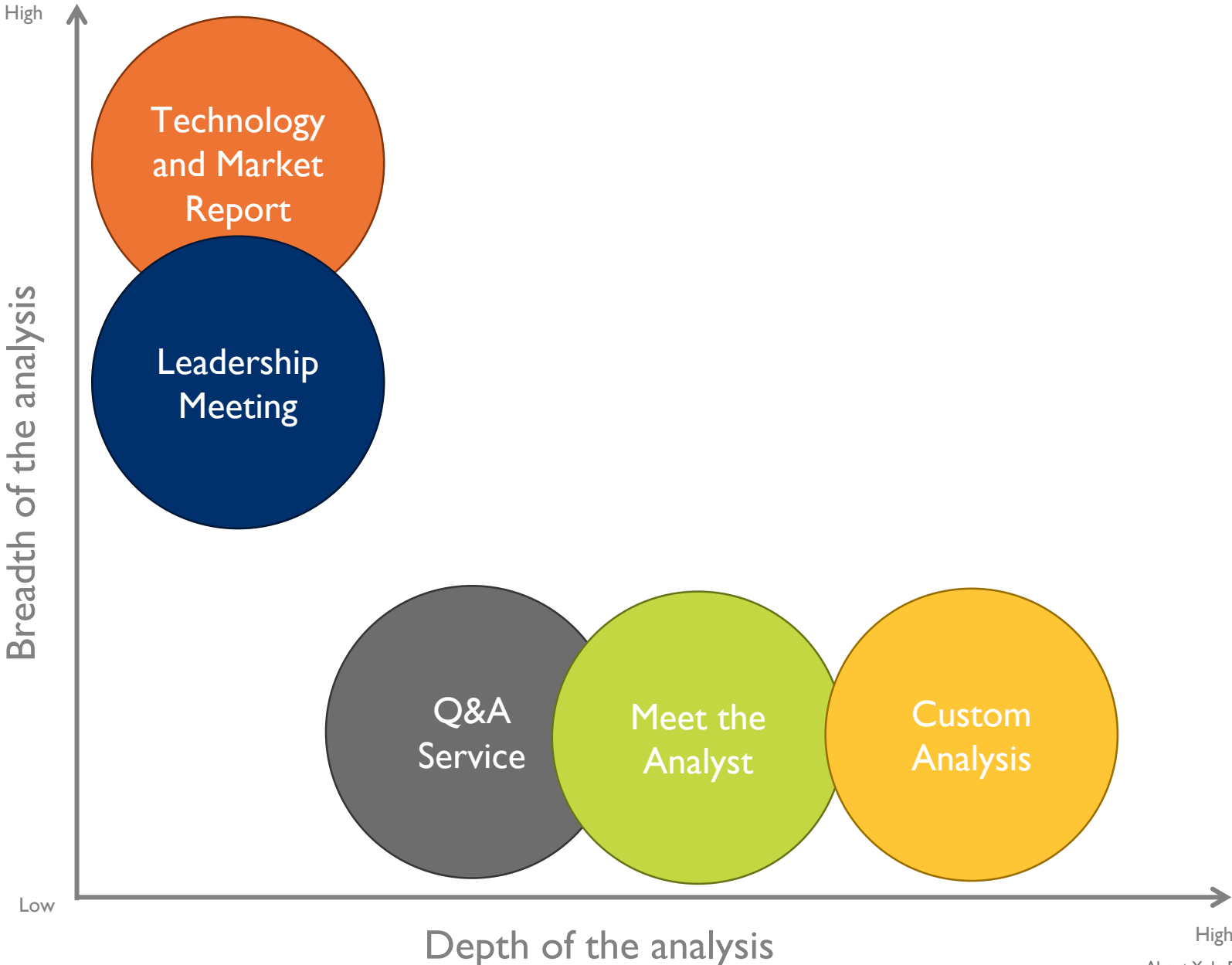
Due diligence

www.yole.fr

OUR GLOBAL ACTIVITY



ANALYSIS SERVICES - CONTENT COMPARISON



SERVING THE ENTIRE SUPPLY CHAIN



Integrators, end-users and software developers

DENSO
Crafting the Core



SONY

Canon

Panasonic



TOSHIBA
Leading Innovation >>>

Device manufacturers



InvenSense



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



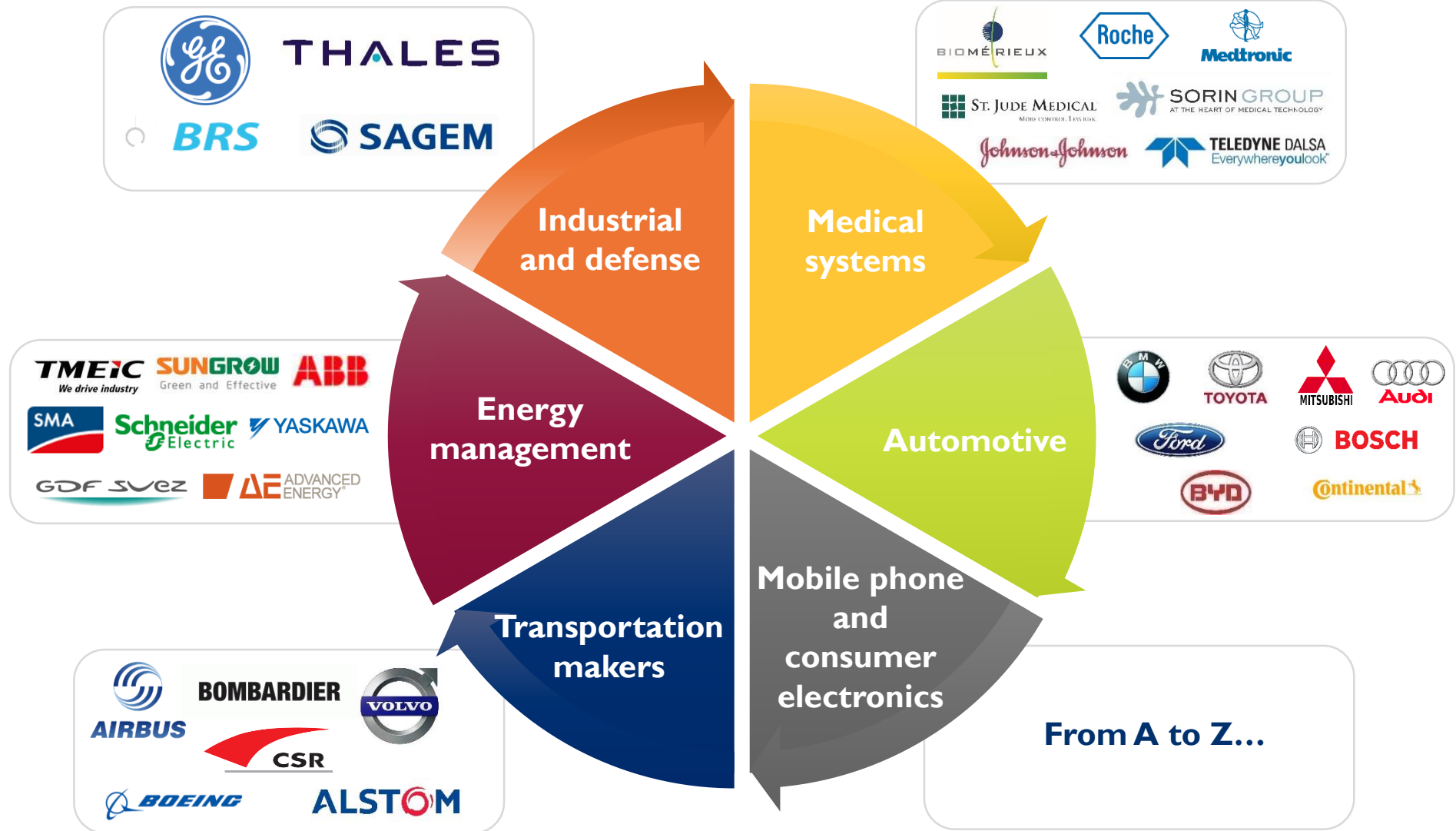
Financial investors, R&D centers

Our analysts provide market analysis, technology evaluation, and business plans along the entire supply chain

SERVING MULTIPLE INDUSTRIAL FIELDS



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



REPORTS COLLECTION

- 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

- 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 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!



www.i-Micronews.com



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.

Reverse Costing® – Structure, Process and Cost Analysis – by System Plus Consulting

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

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

OUR 2019 REPORTS COLLECTION (2/5)

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

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  
- Next Generation Sequencing & DNA Synthesis - Technology, Consumables Manufacturing and Market Trends 2019 - New 
- 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 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   

OUR 2019 REPORTS COLLECTION (3/5)

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

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 Advanced Packaging Industry 2019 - Update      
- Status of Advanced Substrates 2019 - Update      
- Panel Level Packaging Trends 2019 - Update      
- Automotive Packaging 2019 - New      
- Trends in Automotive Packaging 2018 
- Thin-Film Integrated Passive Devices 2018      

○ STRUCTURE, PROCESS & COST REPORT

- Advanced RF SiP for Cellphones Comparison 2019 

OUR 2019 REPORTS COLLECTION (4/5)

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

SEMICONDUCTOR MANUFACTURING

○ MARKET AND TECHNOLOGY REPORT

- Nano Imprint 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 
- Automotive Lighting 2018: Technology, Industry and Market Trends 
- 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     
- Technologies And Markets for Next Generation Televisions 
- Displays & Optical Vision Systems for VR, AR & MR 2018  

○ PATENT REPORT

- MicroLED Displays : Intellectual Property Landscape 2018 

OUR 2019 REPORTS COLLECTION (5/5)

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

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  

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     



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*

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.

- **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.



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

PATENT MONITOR by KnowMade

A FULL PACKAGE:

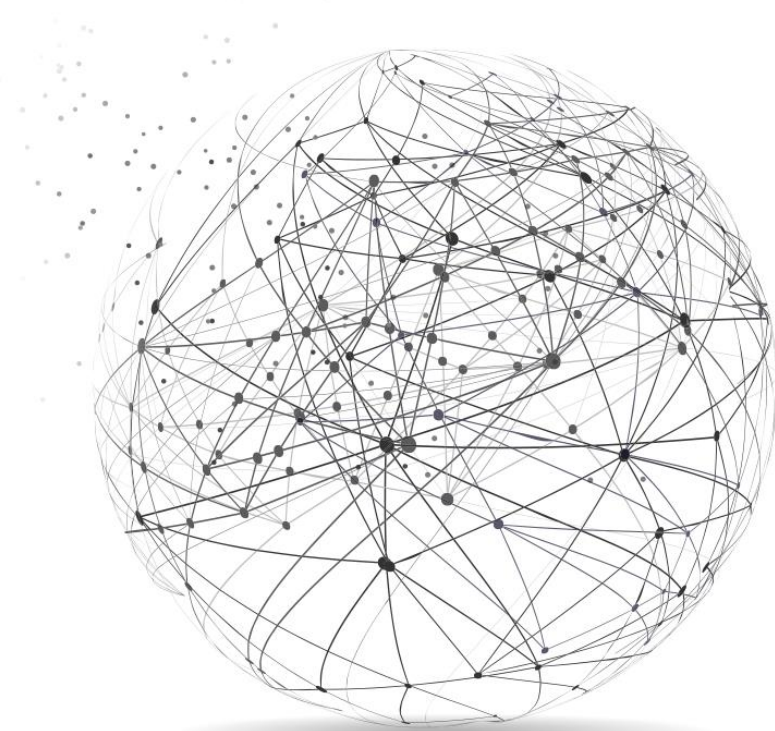
Starting at the beginning of the year, the KnowMade monitors include the following deliverables:

- 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.



To meet the growing demand for market, technological and business information, i-Micronews Media integrates several tools able to reach each individual contact within its network.

We will ensure your company benefits from this



ONLINE

i-Micronews e-newsletter
i-Micronews.com
FreeFullPDF.com

Unique, cost-effective ways to reach global audiences.

Online display advertising campaigns are great strategies for improving your product/brand visibility. They are also an efficient way to adapt with the demands of the times and to evolve an effective marketing plan and strategy.

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

ONSITE

Events

Brand visibility, networking opportunities

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

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

INPERSON

Webcasts

Targeted audience involvement equals clear, concise perception of your company's message.

Webcasts are a smart, innovative way of communicating to a wider targeted audience. Webcasts create very useful, dynamic reference material for attendees and also for absentees, thanks to the recording technology.

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

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

CONTACT INFORMATION

○ CONSULTING AND SPECIFIC ANALYSIS, REPORT BUSINESS

• North America:

- **Steve LaFerriere**, Senior Sales Director for Western US & Canada
Email: laferriere@yole.fr – +1 310 600-8267
- **Chris Youman**, Senior Sales Director for Eastern US & Canada
Email: chris.youman@yole.fr – +1 919 607 9839

• Japan & Rest of Asia:

- **Takashi Onozawa**, General Manager, Asia Business Development (India & ROA)
Email: onozawa@yole.fr - +81 34405-9204
- **Miho Ohtake**, Account Manager (Japan)
Email: ohtake@yole.fr - +81 3 4405 9204
- **Itsuyo Oshiba**, Account Manager (Japan & Singapore)
Email: oshiba@yole.fr - +81-80-3577-3042

- **Korea: Peter Ok**, Business Development Director
Email: peter.ok@yole.fr - +82 10 4089 0233

- **Greater China: Mavis Wang**, Director of Greater China Business Development
Email: wang@yole.fr - +886 979 336 809

- **Europe: Lizzie Levenez**, EMEA Business Development Manager
Email: levenez@yole.fr - +49 15 123 544 182

- **RoW: Jean-Christophe Eloy**, CEO & President, Yole Développement
Email eloy@yole.fr - +33 4 72 83 01 80

○ FINANCIAL SERVICES (in partnership with Woodside Capital Partners)

- **Jean-Christophe Eloy**, CEO & President
Email: eloy@yole.fr - +33 4 72 83 01 80
- **Ivan Donaldson**, VP of Financial Market Development
Email: ivan.donaldson@yole.fr - +1 208 850 3914

○ CUSTOM PROJECT SERVICES

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

○ GENERAL

- **Camille Veyrier**, Director, Marketing & Communication
Email: veyrier@yole.fr - +33 472 83 01 01
- **Sandrine Leroy**, Director, Public Relations
Email: leroy@yole.fr - +33 4 72 83 01 89 / +33 6 33 11 61 55
- **Email: info@yole.fr** - +33 4 72 83 01 80

