From Technologies to Markets

3D Imaging & Sensing

From enhanced photography to an enabling technology for AR and VR

February 2020

Webcast

YOLE Développement | edge ai + vision ALLIANCE

YOLE DEVELOPPEMENT

3 domains of expertise

Photonics & Sensing

- Photonics
- Lighting
- Imaging
- Sensing & Actuating
- Display

Semiconductor & Software

- Semiconductor Packaging and Substrates
- Semiconductor Manufacturing
- Memory
- Computing and Software

Power & Wireless

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

3D IMAGING & SENSING

From Enhanced Photography to an Enabling Technology for AR and VR

1- Application trend

WHAT ARE WE TALKING ABOUT?

From imaging to sensing

3D imaging for display and 3D sensing for recognition /detection.

Imaging

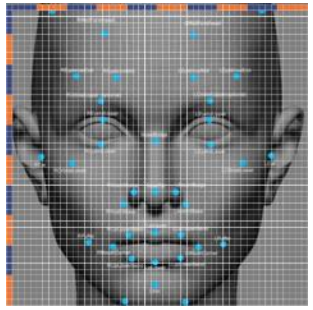
Stereo images

360° images

Image processing/enhancement

Holographic images

Sensing



Facial recognition in mobile

Mapping in GIS

Detection in automotive

ADAS in automotive

Detection in AR/VR

Obstacle avoidance in drone

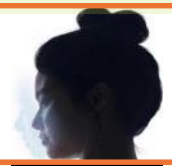
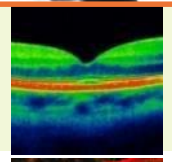
Object recognition in industrial

People counting in surveillance

3D IMAGING & SENSING MODALITIES SEGMENTATION

3D imaging & sensing cover a wide range of modality.

Covered by this presentation

	Modality	3D sensor type
	X-Ray CT	CT scanner, flat panel CT, cone beam CT
	Optical 3D	Structure from motion, stereo cameras, projection based cameras, time of flight cameras
	Optical CT	Spectral domain OCT, swept source OCT
	Lidar	Lidar, solid state Lidar, MEMS Lidar, Flash Lidar
	Radar	Synthetic aperture radars
	Ultrasound	Phased arrays

USE OF MACHINE VISION TECHNOLOGY

Vision sensing technology is transforming all markets

Robotics and immersive technologies are transforming the imaging landscape.

Image generation is less often intended for human usage.

Machines have a greater requirement for sensory input for autonomy & interaction.

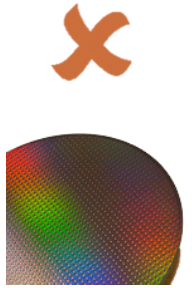
3D imagers & sensors are a key part of this technology revolution.

WHAT ARE WE TALKING ABOUT?

3D imaging & sensing from sub-components to camera modules

Minimum resolution for imaging
50 pixel x 50 pixel arrays

Analysis from component point of view.

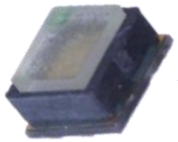


Courtesy of Sony

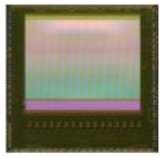
Wafers & raw material

Semiconductor level

VCSEL



Emitter



Receiver Sensor array

Lens

Semiconductor & Other Sub-components

Module level

Assembly

Courtesy of Sunny Optical

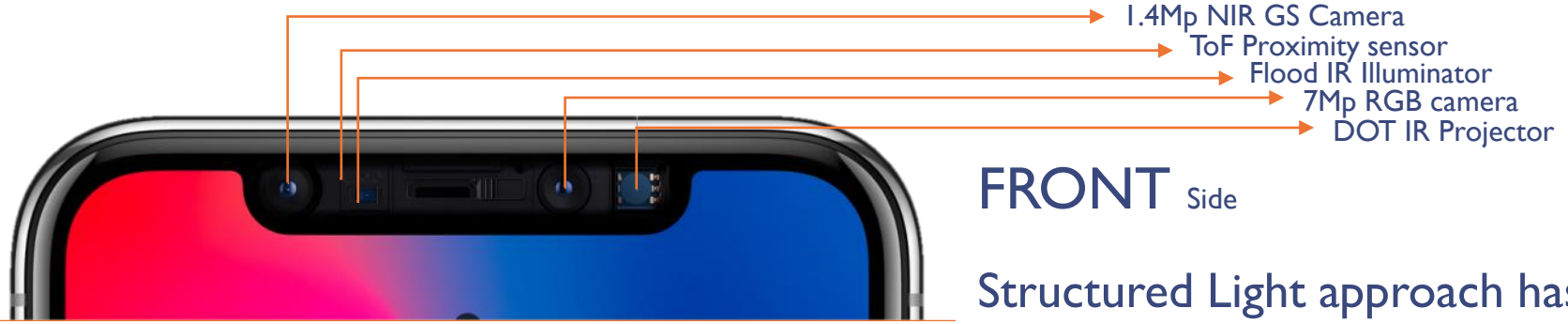
Camera module

Courtesy of OPPO

Systems

3D IMAGING AND SENSING FOR MOBILE PHONES

2017



FRONT Side

Structured Light approach has been chosen as a starting point for the 3D imaging era. The front 3D module could evolve toward ToF technology in the future, showing more reliability in direct sunlight and lower computational requirements.

Beginning of the 3D imaging era

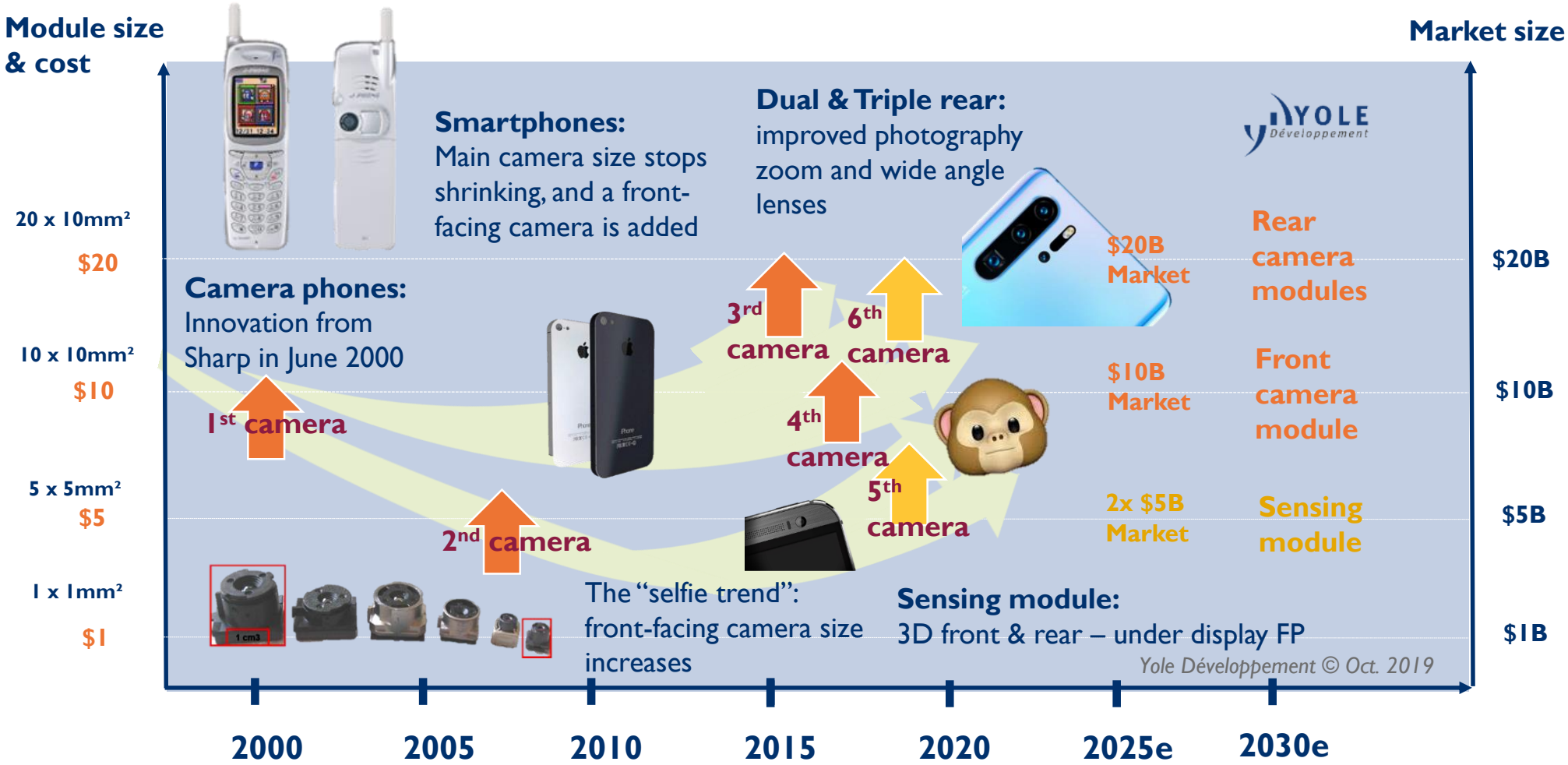
2019

REAR Side

ToF technology is used in REAR side in 2019 for photograph enhance. It developed more applications such like AR game, 3D measurement etc.. It has some advantage such like longer work distance, smaller size and less cost etc., it will grow fast and eventually will encroach the mobile 3D market more in future.

MOBILE MARKET TREND

Proliferation of cameras in mobile - historical



MOBILE MARKET TREND

CMOS image sensor - market drivers

Mobile drivers are sometime pulling in different directions.

3 Drivers

Image quality

Leading smartphone cameras are expected to deliver « DSLR-like » image quality
→Indoor and nighttime conditions
→High-resolution **photography** and video (4k)
→High-speed AF and OIS
→Zoom capability
→Slow motion

User interface

Beyond the touchscreen, smartphone makers want to improve the user experience:
→Removal of the physical button
→Biometric unlocking (3D sensing or underdisplay fingerprint cameras)
→Virtual reality **interactions**

Aesthetics

Thin **form-factor** and borderless screens have become mandatory
→Lower F# optics (high CRA)
→Multiple camera approaches
→Front-side camera conundrum

MOBILE MARKET TREND

CMOS image sensor - market drivers

Mobile drivers are sometime pulling in different directions.

3 Drivers

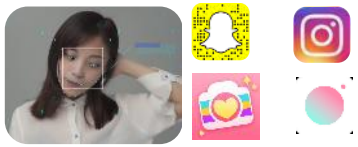
	Image quality	User interface	Aesthetics
	Proliferation of cameras	**3D sensing & biometry**	**Edge to edge displays visible attribute**
Front 3D	✓	✓	✗
Rear 3D	✓	✓	✓

MOBILE 3D CAMERA IMPLEMENTATIONS

Use-cases and opportunities for the front 3D camera

- **Easy unlocking**   ✓
- **Security** (Facial recognition)   ✓
- **Morphing** (Augmented reality)   ✓
- **Gaming** (Avatar)   ~
- **Enhanced video call**   Market is expending thanks to Apple
- **Holographic displays**  

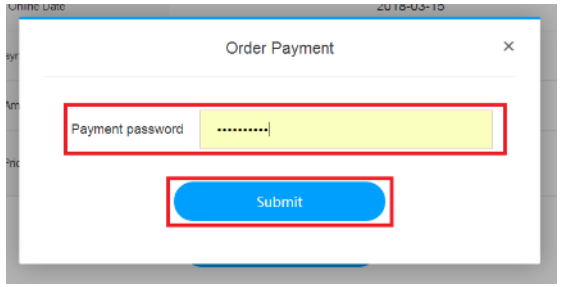
Use-cases and opportunities for the rear 3D camera

- **Better photography**  ✓
- **Augmented reality**  ~
- **Gaming**  ~
- **Commerial** 
- **3D print**  Market had a good start with Huawei
- **Other?** 

MOBILE APPLICATION – FRONT 3D IMAGING & SENSING

Password to facial payment （1/3）

Evolution of payments.



Password payment

Fingerprint payment

Facial recognition payment

With 3D imaging and sensing, the payment can use facial recognition to replace the password and fingerprint.

- ✓ Easy use
- ✓ Most security
- ✓ Non-contact

支付宝 ALIPAY

Pay

MOBILE APPLICATION – FRONT 3D IMAGING & SENSING

From animoji to morphing (2/3)

Whatever animoj or morphing, it relies on the 3D imaging.

Apple (2017)

With 3D sensing, facial expression is uploaded to the app and then itself modified using a digital avatar

This has significant implications on Vblog, video call and video app, enhance the video effect.

Note : The 3D module is used to make the original calibration then the tracking of the face is done through the 2D camera. The 3D module is too power consuming to be used to track the face all the time

MOBILE APPLICATION – REAR 3D IMAGING & SENSING

Photography enhance is a key applications for rear 3D in the phone.

Bokeh

Body/Face shaper

Image render

MOBILE APPLICATION – REAR 3D IMAGING & SENSING

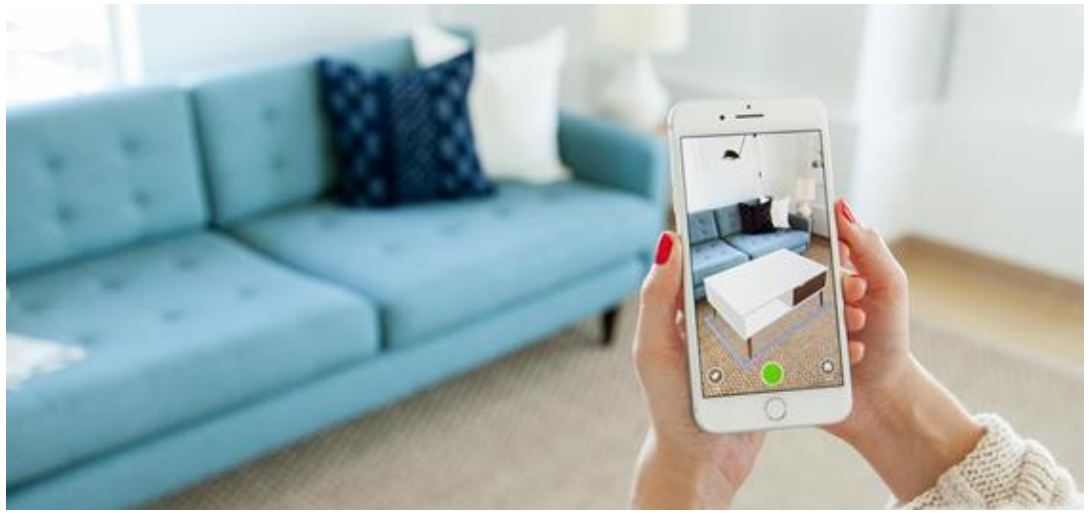
3D commercial applications are everywhere.

EC site buyer

Cloth fitting

AR Advertisement

City navigation



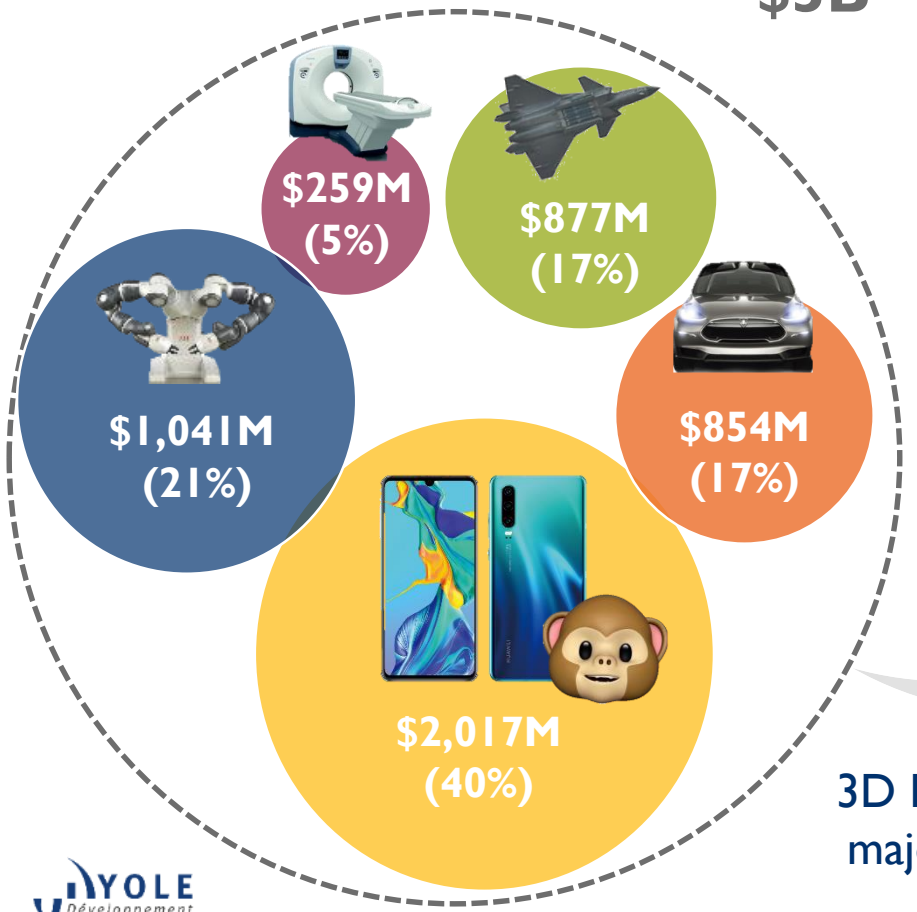
Object measurement

2 – Market Forecast

3D SENSING AND IMAGING - 2019-2025 MARKET FORECAST (IN $M)

- Defense & aerospace
- Industrial
- Medical
- Automotive
- Mobile & consumer

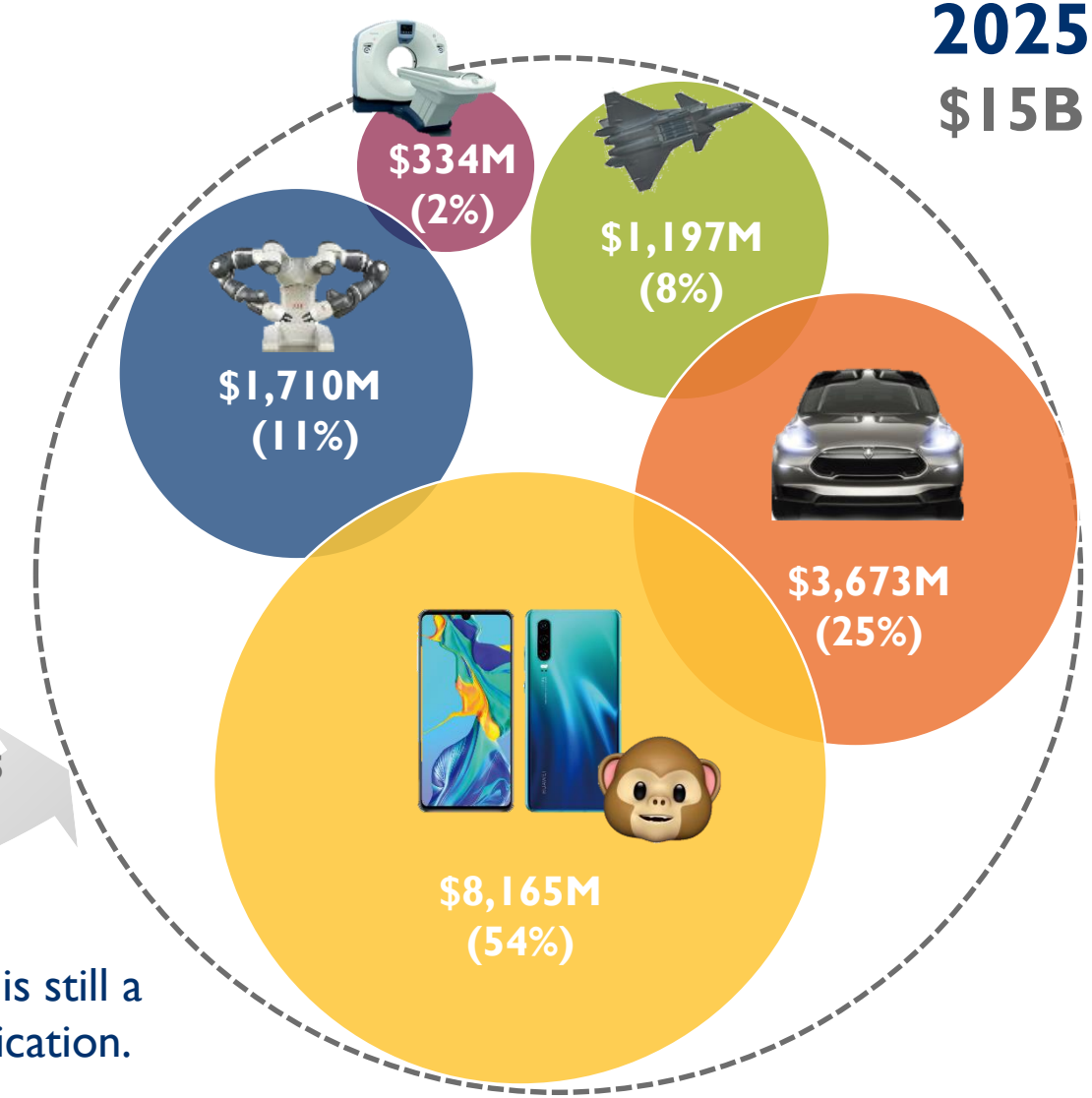
2019
$5B



$CAGR_{2019\text{-}2025}$ +20%

3D Imaging & Sensing is still a major consumer application.

2025
$15B



MOBILE MARKET TREND

3D camera adoption scenario

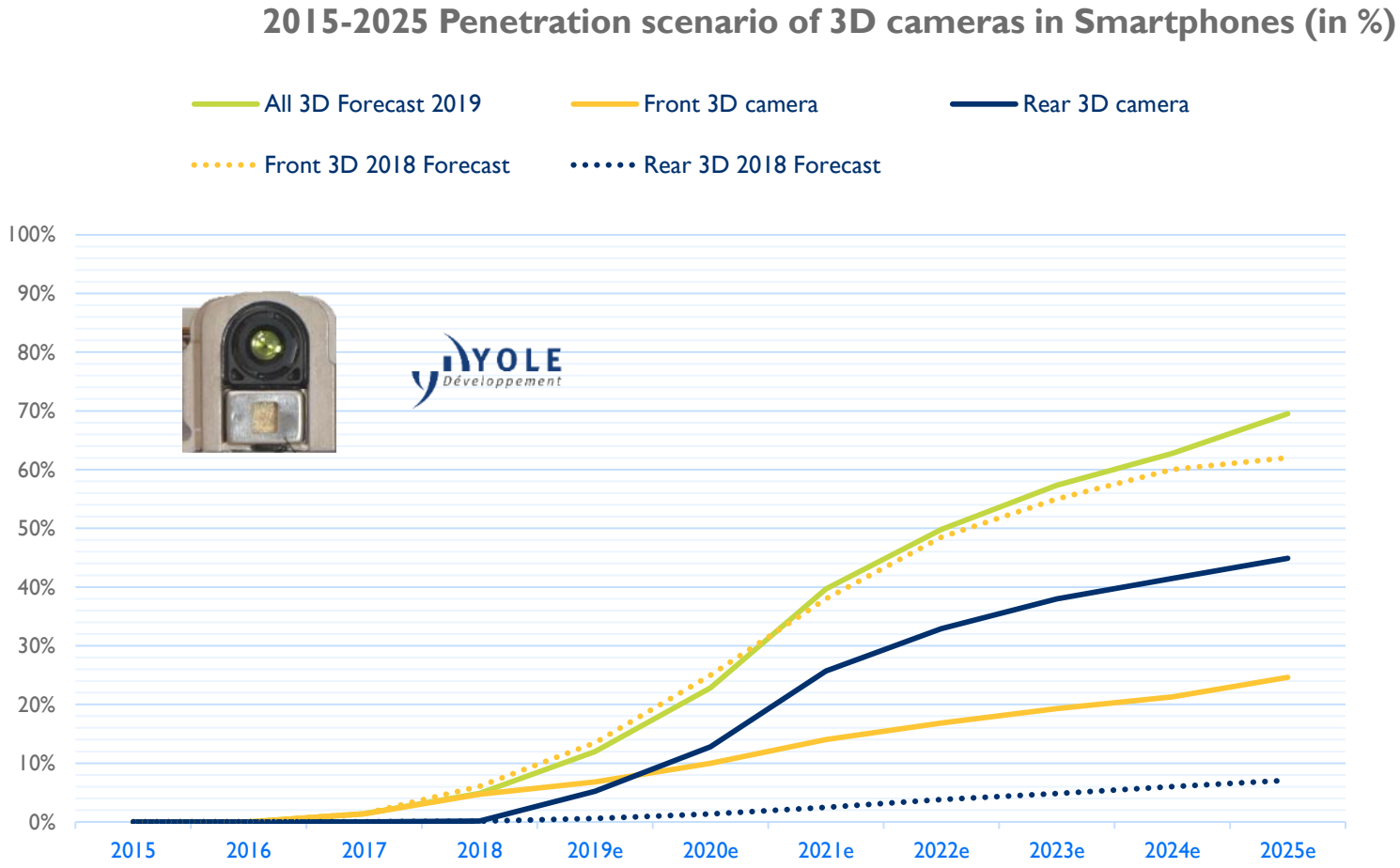
3D sensing adoption switches to the rear.

The original adoption scenario was coined on similar smartphone hardware adoption curves (FP, IMU combos)

In 2017 Apple started to attach a front 3D camera for face unlock

In 2019 Huawei switched the adoption from the front to the rear

Overall the 3D sensing forecast remains more or less on track, the ratios rear and front are totally reversed



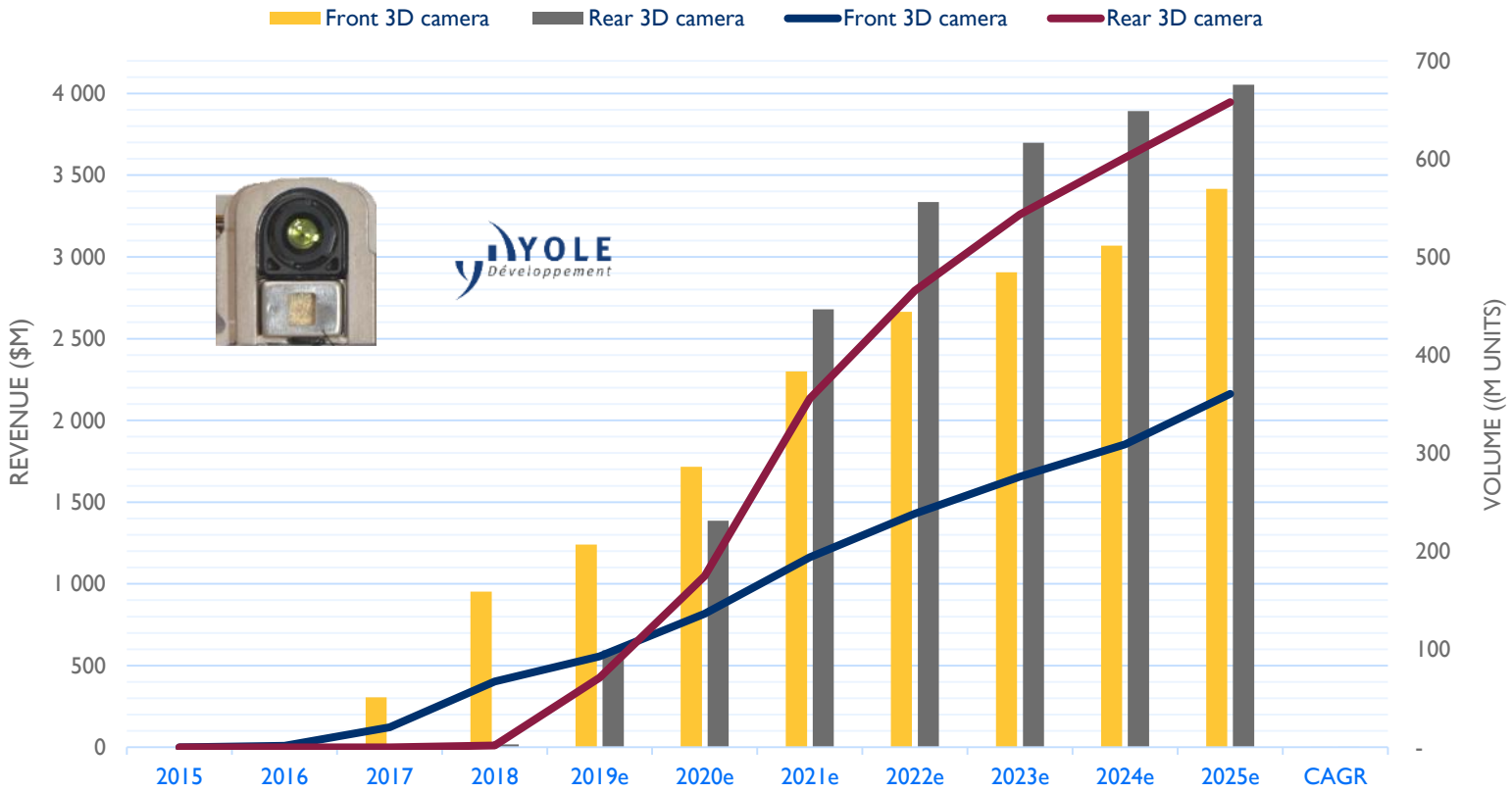
3D IMAGING & SENSING MARKET FORECAST

Mobile front and rear 3D camera market forecast

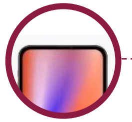
Rear 3D camera is rise rapidly.

From OPPO, Vivo, Huawei and then Samsung, Android makers quickly adopted ToF as its 3D rear camera, and the volume and revenue increased accordingly. Yole expect that ToF will surpass structured light in the next 1-2 years.

2015-2025 Mobile front and rear 3D camera market forecast ($M and M units)



MARKET & TECHNOLOGY ROADMAP

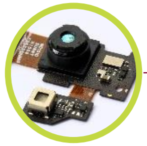


2024

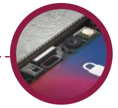
2022

2021

2020



2019



2018

	FRONT		REAR
2024		Rear 3D technology did start with ToF while Front 3D technology will transition to ToF	
2022	AS / SL / ToF (0%–100%) Volume 238Mu	Under display 3D ToF ?	AS / SL / ToF (0%–100%) Volume 466Mu
2021	AS / SL / ToF (0%–100%) Volume 194Mu	Direct Time of Flight?	AS / SL / ToF (0%–100%) Volume 356Mu
2020	AS / SL / ToF (0%–100%) Volume 136Mu	QD Structured light	AS / SL / ToF (0%–100%) Volume 175Mu
2019	AS / SL / ToF (0%–100%) Volume 93Mu	Indirect Time of Flight	AS / SL / ToF (0%–100%) Volume 71Mu
2018	AS / SL / ToF (0%–100%) Volume 67Mu	Structured Light	AS / SL / ToF (0%–100%) Volume 2Mu

3D sensing volume reaches 50% of mobile volume

2022

Front 3D would represent 1/6 of mobile volume

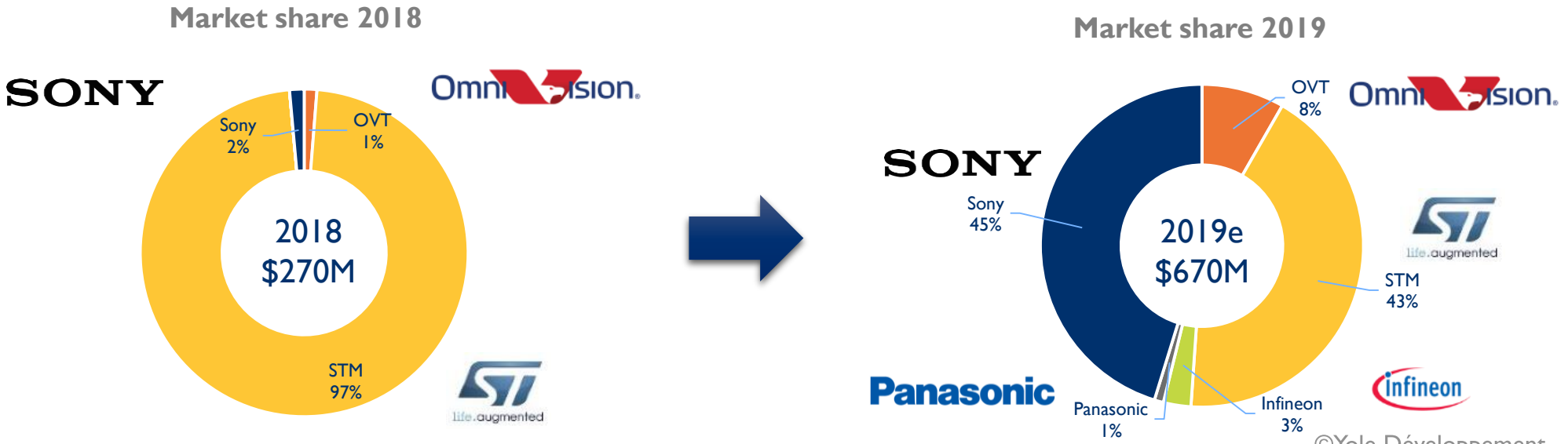
Rear 3D would represent 1/3 of mobile volume

3 – Company Ecosystem

2019 CIS NIR & TOF SENSING MARKET SHARE ANALYSIS

Mobile & Consumer – Semiconductor level

STM and Sony are sharing the market in almost equal proportions.



- ST Microelectronics has been Apple's NIR sensor supplier since 2017, it's big winner in the structure light market of mobile phone but it's highly rely on it.
- Sony is supplying the ToF sensor to Android-based smartphone and quickly gained a large market share in 2019, it's highly involved in Huawei and Samsung mobile supply chain and this relation is expected to continue.
- OVT got several design-win from Android comp. such like OPPO and Huawei for the structure light, however, due to these players are stagnant later in 2019, it's growing slowly.

2019 VCSEL MARKET SHARE ANALYSIS

All markets – Semiconducor level

3D sensing is changing the ranking in the VCSEL market.

©Yole Développement – 2019

- AMS (Princeton Optronics) has been highly involved in Android-based smartphones and this trend is expected to continue in 2020.
- Finisar has been qualified by Apple and should grab some market share from Lumentum with the manufacture of VCSEL for the Face ID module. Moreover, II-VI is expected to be qualified by Android-based smartphone manufacturers, giving it the opportunity to enter the consumer market.
- Trumpf is highly involved in STMicroelectronics' supply chain and this relation is expected to continue. Some design wins with Android-based smartphone manufacturers should complete its activity in the consumer market.

3D IMAGING AND SENSING - SUPPLY CHAINS

Structured Light

	Emitter/VCSEL/Diffractive grating	Receiver/CIS Die	Module Maker
 Apple iPhone Xs, Xr	LUMENTUM, ams	ST life.augmented	FOXCONN, SHARP, LG Innotek
 Xiaomi Mi8 Released May 2018.	ams, FINISAR, II-VI, TRULY	OmniVision	OFILM
 Oppo Find X Released July 18, 2018.	LUMENTUM, ams, Q Tech	OmniVision	SUNNY OPTICAL TECHNOLOGY
 Huawei Mate 20 Pro Released November 2018	LUMENTUM, ams	OmniVision	SUNNY OPTICAL TECHNOLOGY, LUXVISIONS

3D IMAGING AND SENSING - SUPPLY CHAINS

ToF

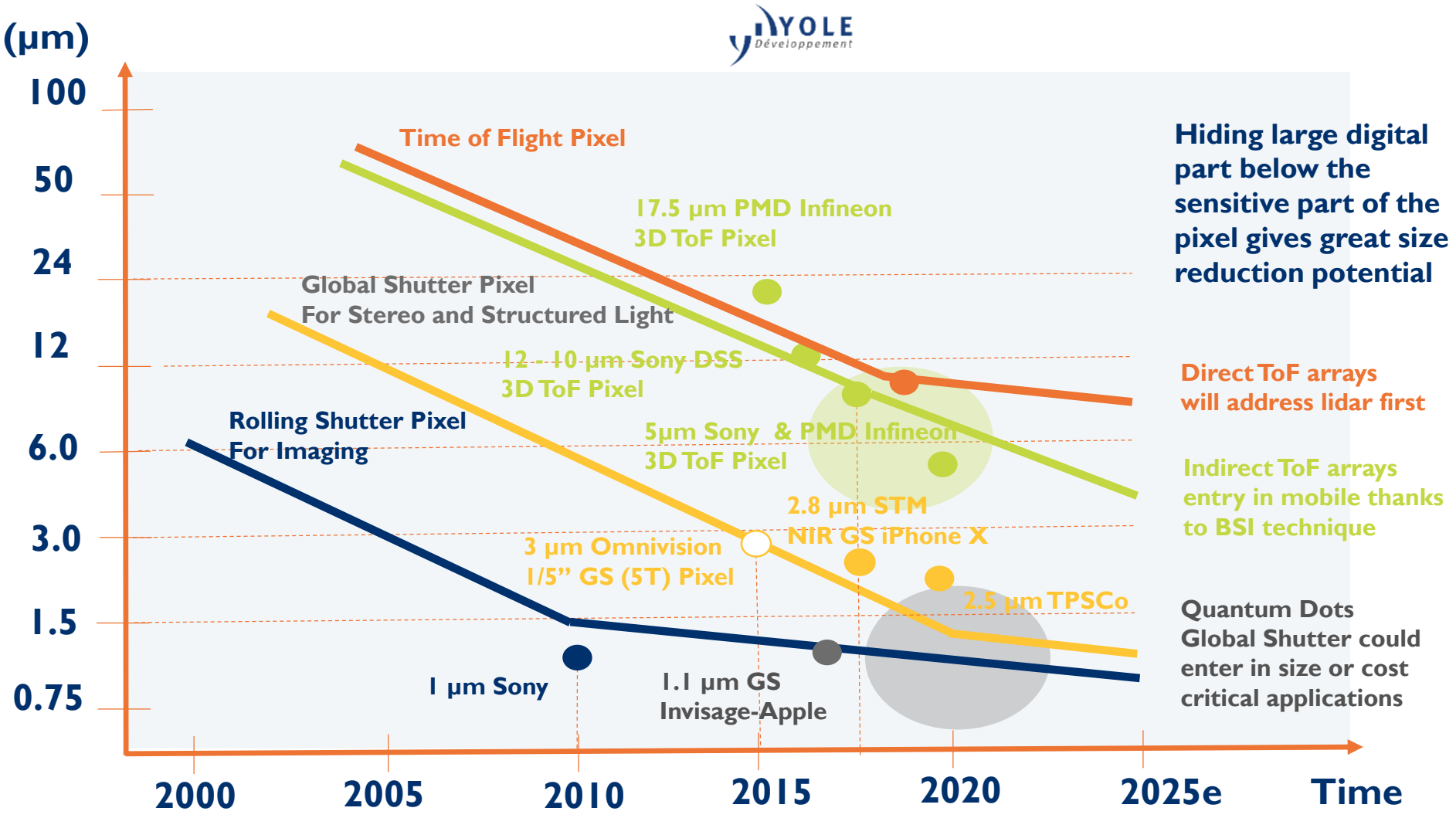
	Emitter/VCSEL	Receiver/ToF Die	Module Maker
Oppo R17 Pro Released Aug 2018 	LUMENTUM VIAVI	SONY	SUNNY OPTICAL TECHNOLOGY
Vivo NEX Dual Display Released Dec 2018 	ams	Panasonic	OFILM
LG G8 ThinQ Released April 2019 	ams	Infineon	LG Innotek
Note 10+ Released Aug 2019 SAMSUNG 	TRUMPF PHILIPS Photonics	SONY	SAMSUNG ELECTRO-MECHANICS
HUAWEI Huawei Mate30 Pro Released Oct 2019 	Vertilite VIAVI	SONY	SUNNY OPTICAL TECHNOLOGY LUXVISIONS Innovation Limited

4 – Technology trend

PIXEL SIZE ROADMAP

Pixels are shrinking with time

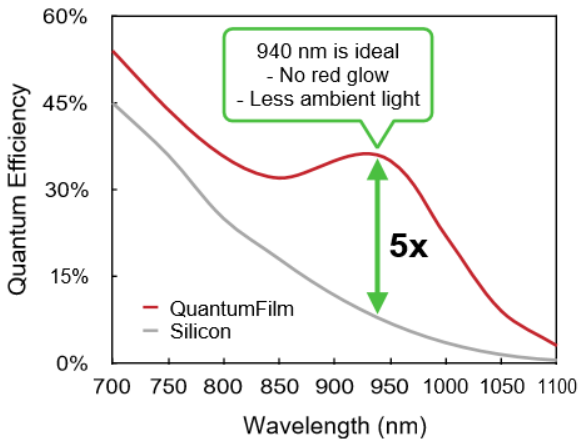
Depending on the technology, the potential for pixel shrink varies.



3D IMAGING AND SENSING TECHNOLOGY

Global shutter pixels for consumer applications?

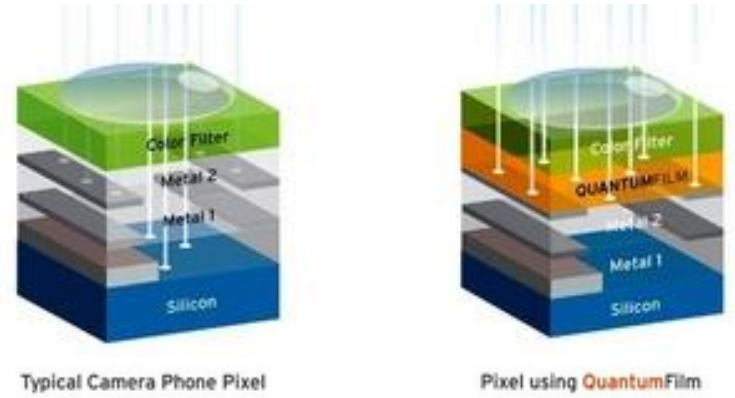
Sensitivity in the near-infrared spectrum is key for active imaging. The quantum dot option could help shrink current approaches.



Quantum dot and similar organic approaches

InVisage

Acquired in Nov. 2017

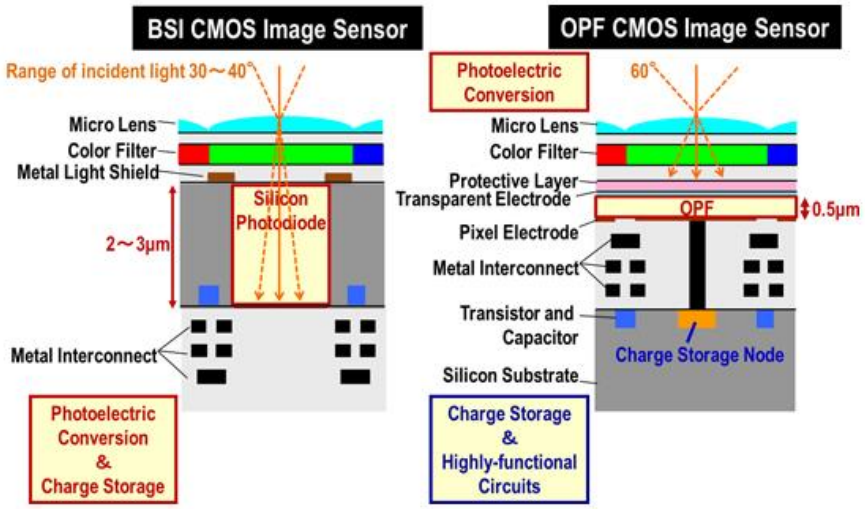


Typical Camera Phone Pixel

Pixel using QuantumFilm

In February 2017 Invisage released a 1.1um GS sensor

Panasonic



Panasonic has developed a similar technology called OPF

3D IMAGING AND SENSING TECHNOLOGY

Apple notch halved or under display ?

NIR GS camera 1.2Mp 3µm

Proximity + flood illumimator

RGB camera 8Mp 1µm

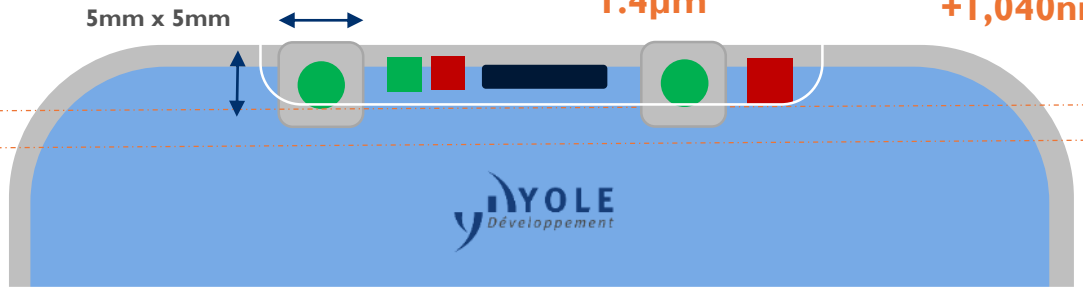
Dot illuminator

NIR GS quantum dot (QD) 2Mp 1µm

Flood proximity + ALS

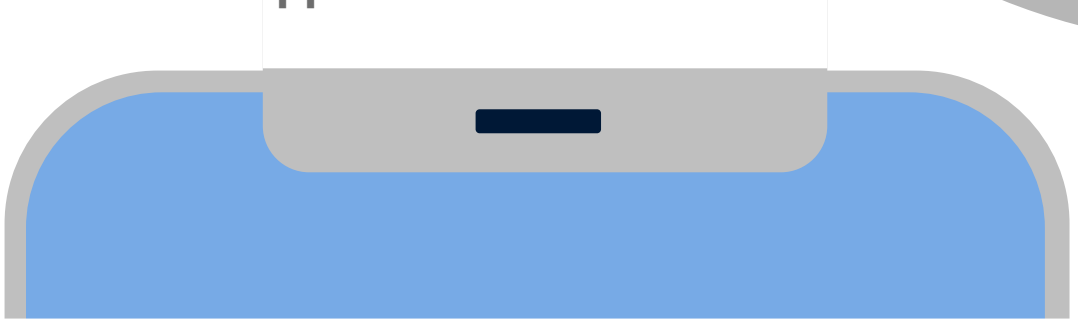
RGB AF + OIS super-resolution 3Mp-12Mp-27Mp 1.4µm

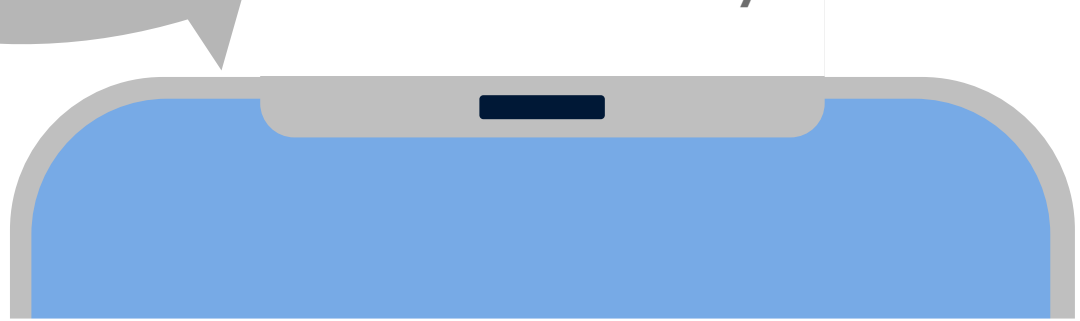
Dot illuminator VCSEL + MLA +1,040nm



3D structured light approach will shrink down

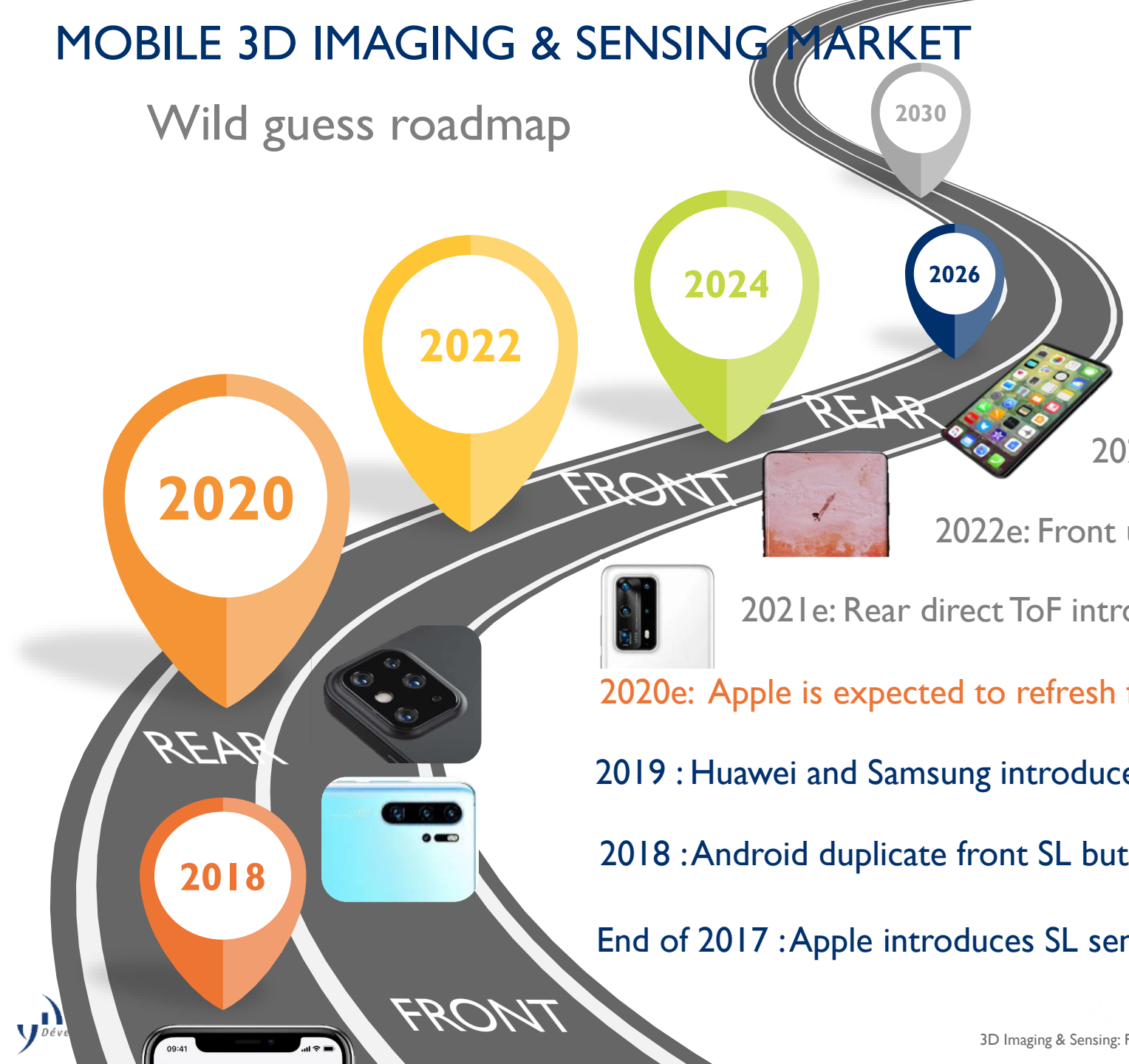
All players remain, but silicon content may shrink





MOBILE 3D IMAGING & SENSING MARKET

Wild guess roadmap



2024e: Next big hardware overall for Apple

2022e: Front underdisplay ToF (LG?)

2021e: Rear direct ToF introduction (Huawei?)

2020e: Apple is expected to refresh front SL and introduce rear ToF

2019 : Huawei and Samsung introduce rear ToF sensor with great success

2018 : Android duplicate front SL but do not sustain the effort

End of 2017 : Apple introduces SL sensor on the front with great success

Thank you

YOLE Développement

YOLE DEVELOPPEMENT

This presentation is based on 2 recently published Yole reports

3D Imaging & Sensing 2020

Status of the CIS Industry 2019

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Your contact: Sandrine Leroy, Dir. Public Relations
Email: leroy@yole.fr

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The Edge AI and Vision Alliance (www.edge-ai-vision.com) is a partnership of ~100 leading edge AI and vision technology and services suppliers, and solutions providers

Mission: To inspire and empower engineers to design products that perceive and understand.

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- *"Fantastic. Learned a lot and met great people."*
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Yole Développement

From Technologies to Market

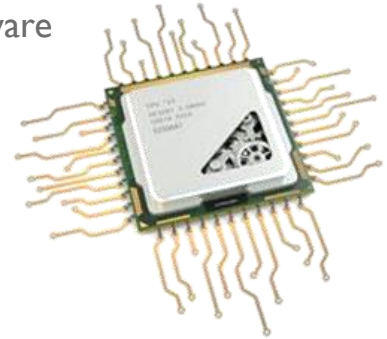
YOLE DEVELOPPEMENT – FIELDS OF EXPERTISE WITHIN 3 MAIN DOMAINS

Photonics & Sensing

- Photonics
- Lighting
- Imaging
- Sensing & Actuating
- Display

Semiconductor & Software

- Semiconductor Packaging and Substrates
- Semiconductor Manufacturing
- Memory
- Computing and Software



Power & Wireless

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

4 BUSINESS MODELS

Consulting and Analysis

- Market data & research, marketing analysis
- Technology analysis
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- Design and characterization of innovative optical systems
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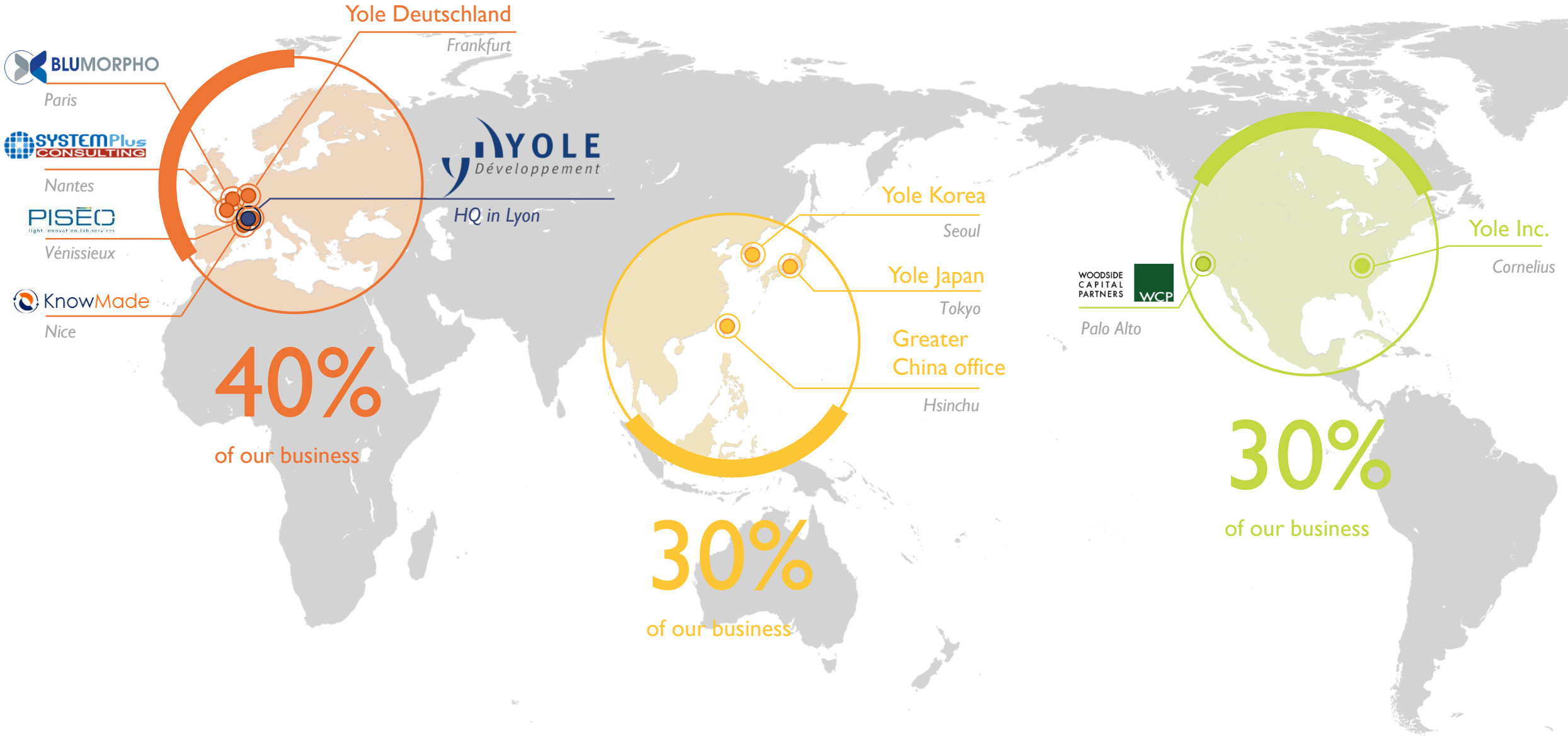
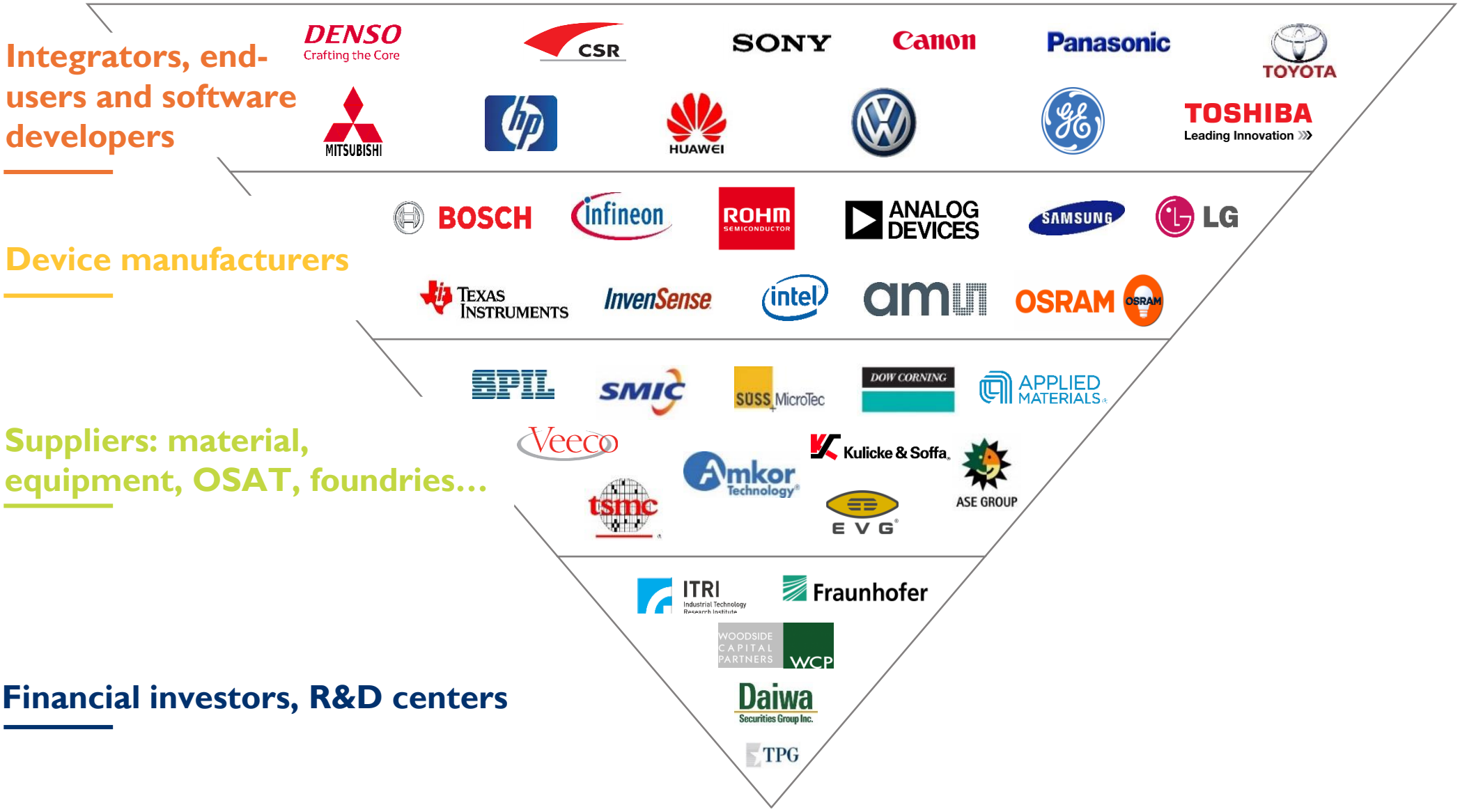


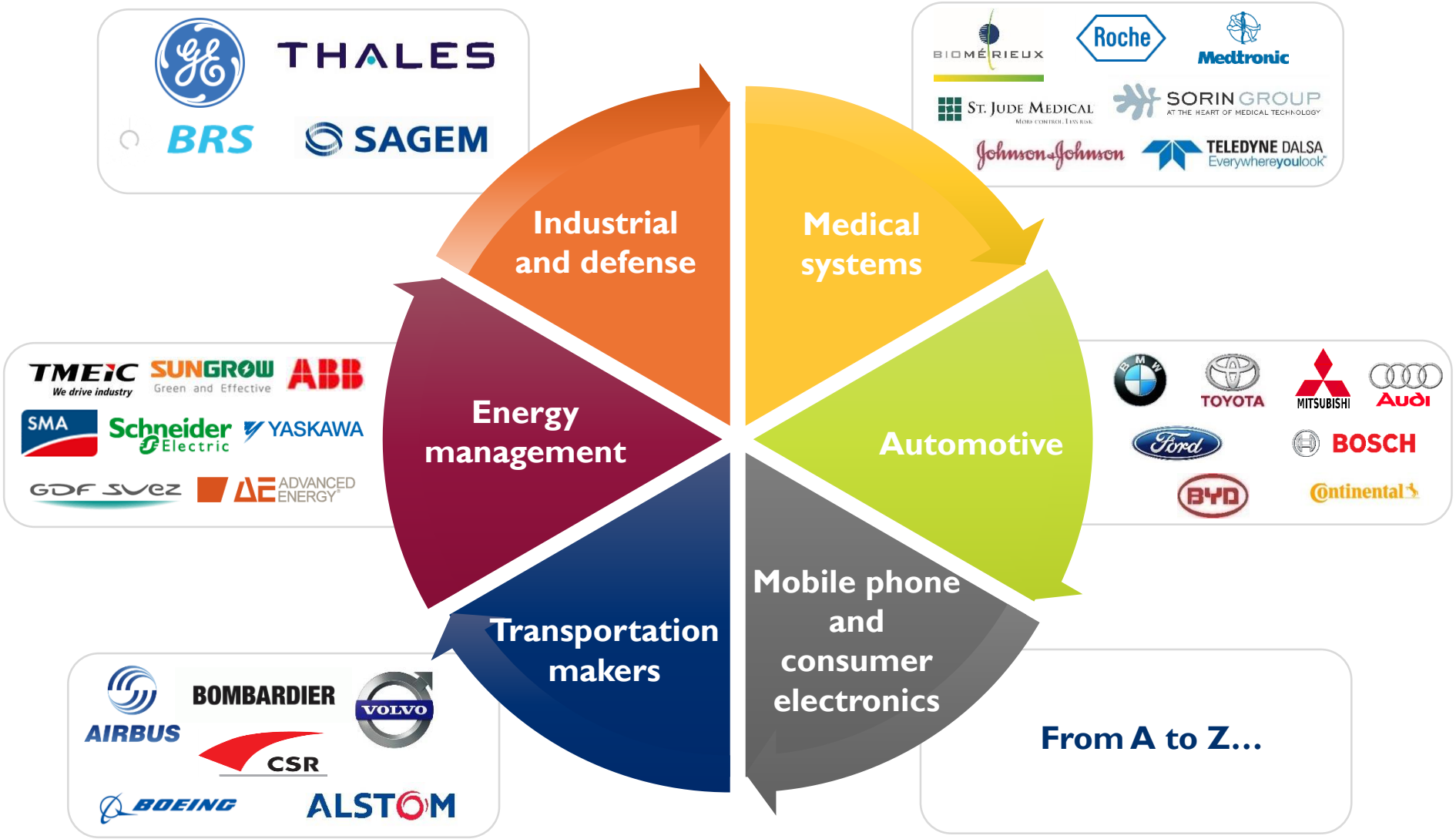
SERVING THE ENTIRE SUPPLY CHAIN

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, MONITORS AND TRACKS COLLECTION

Over 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 as well as intellectual property (IP) and patent analysis. Together, our group of companies is collaborating ever more closely. In 2020, we therefore will offer a collection of over **125 syndicated reports, 11 monitors and 160 teardowns**. Combining the respective expertise and methodologies from the three companies, our products 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
- Computing & Software
- Imaging
- Photonics

www.i-Micronews.com

Our team of analysts, including **PhD and MBA qualified industry experts** from Yole Développement, System Plus Consulting and KnowMade, collect and analyse 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 2,300 projects, interacting with technology professionals and high-level opinion makers from the main players in their industries and completed more than **5,000 interviews per year**.

WHAT TO EXPECT IN 2020?

During 2019 we introduced new additions to our "**monitor**" product offering, which provides continual updates on your industry during the year, and we will be expanding this offering during 2020. In addition to the monitors, we also developed "**teardown tracks**' that provide you online visibility into the latest consumer technology product designs and the suppliers within them. In 2020, an automotive track will be launched, further expanding our research focused on emerging technologies. On our traditional **report** side of our business, the Yole Group continues our commitment to a new collection of reports addressing six key markets: **Mobile & Consumer, Automotive & Transportation, Telecom & Infrastructure, Medical, Industrial, and Defense & Aerospace**. Discover our 2020 program right now, and ensure you get a true vision.

OUR 2020 REPORTS COLLECTION (1/4)

BATTERY AND ENERGY MANAGEMENT

MARKET & TECHNOLOGY REPORT

- Li-ion Battery Packs for Automotive and Stationary Storage Applications 2020
- Li-ion Battery Recycling Industry: Technology Trends and Supply Chain Analysis 2020
- Status of Rechargeable Li-ion Battery Industry 2019

PATENT LANDSCAPE REPORT

- Solid-State Li-ion Batteries 2020
- Silicon Anode for Li-ion Batteries 2020

COMPOUND SEMICONDUCTORS AND EMERGING MATERIALS

MARKET AND TECHNOLOGY REPORT

- GaAs Wafer and Epiwafer Market: RF, Photonics, LED and PV Applications 2020
- InP Wafer and Epiwafer Market – Photonic and RF Applications 2020
- Power SiC : Materials, Devices and Applications 2020
- Power GaN : Epitaxy, Devices, Applications, and Technology Trends 2020
- RF GaN Market: Applications, Players, Technology, and Substrates 2020
- Status of SOI and Innovative Engineered Substrates: Players, Applications and Technology Trends 2020
- Emerging Semiconductor Substrates: Market & Technology Trends 2019

STRUCTURE, PROCESS & COST REPORT

- GaN Transistors Comparison 2020
- SiC Diodes Comparison 2020
- SiC Transistors Comparison 2020
- GaN-Based Wall Charger Comparison 2019
- GaN-on-Si HEMT vs Superjunction MOSFET Comparison 2019

PATENT LANDSCAPE REPORT

- Power GaN 2019
- Power SiC: MOSFETs, SBDs and Modules 2019

COMPUTING AND SOFTWARE

MARKET & TECHNOLOGY REPORT

- Artificial Intelligence for Surveillance & Security 2020
- Artificial Intelligence for Automotive including IP 2020
- (x)PU: CPU and GPU for High-End Datacenter Applications 2020: Cloud Gaming and HPC
- Artificial Intelligence Computing for Consumer 2019
- Image Signal Processor and Vision Processor Market and Technology Trends 2019

DISPLAY

MARKET & TECHNOLOGY REPORT

- Displays & Optics for VR, AR & MR 2020
- Microdisplays Technologies & Market Trends 2020
- MicroLED Displays - Market, Industry and Technology Trends 2020
- MicroLED Displays - Intellectual Property Trends 2020
- Next Generation 3D Displays 2019
- Next-Generation Human Machine Interaction in Displays 2019
- Next Generation TV Panels: New Technologies, Features and Market Impact 2019

OUR 2020 REPORTS COLLECTION (2/4)

IMAGING

MARKET AND TECHNOLOGY REPORT

- Ga2D and 3D Machine Vision for Industrial Applications 2020
- 3D Sensing & Imaging 2020
- Artificial Intelligence for Medical Imaging 2020
- Status of the Camera Module Industry 2020
- Status of CMOS Image Sensor Industry 2020
- Status of the Medical Imaging 2020
- Thermal Imaging 2020
- Imaging for Automotive 2019
- Cameras for Microscopy and Next-Generation Sequencing 2019
- Neuromorphic Sensing and Computing 2019
- X-Ray Detectors for Medical, Industrial and Security Applications 2019

STRUCTURE, PROCESS & COST REPORT

- Automotive Camera Module Comparison 2020
- Smartphone Camera Module Comparison 2020 (4 volumes)
- Mobile Camera Module Comparison 2019
- Mobile CMOS Image Sensor Comparison 2019
- Smartphone 3D Sensing & VCSEL Comparison 2020

PATENT LANDSCAPE REPORT

- Artificial Intelligence in Medical Diagnostics 2019

LIGHTING

MARKET & TECHNOLOGY REPORT

- Status of the Solid State Lighting Source Industry 2020
- VCSELs - Market and Technology Trends 2020
- Edge Emitting Lasers: Market and Technology Trends 2019
- Light Shaping Technologies for Consumer and Automotive Applications 2019

MEMORY

MARKET & TECHNOLOGY REPORT

- Emerging Non Volatile Memory 2020
- Front-End Equipment and Materials for Memory: Focus on Market Forecast & Shares 2020
- Memory for Artificial Intelligence Applications 2020: Embedded, Standalone …
- Status of the Memory Industry 2020
- MRAM Technology and Business 2019

STRUCTURE, PROCESS & COST REPORT

- DRAM Memory Comparison 2020
- NAND Memory Comparison 2020
- LPDDR4 Memory Comparison 2019

PACKAGING AND SUBSTRATES

MARKET & TECHNOLOGY REPORT

- 5G Packaging Trends 2020: RF FE Modules & Base Stations
- Fan Out Packaging Technologies and Market 2020
- Status of the Advanced Packaging Industry 2020

OUR 2020 REPORTS COLLECTION (3/4)

PACKAGING AND SUBSTRATES (MORE)

- System in Package (SiP) Technology and Market Trends 2020
- Photonics Packaging and Assembly 2020
- Wafer-Level Chip Scale Packaging 2020
- 2.5D/3D TSV & Wafer-Level Stacking: Technology & Market Updates 2019
- Advanced RF System-in-Package for Cellphones 2019
- Automotive Packaging: Market and Tech. Trends 2019
- Die Attach Equipment Market 2019
- Status of Advanced Substrates 2019

STRUCTURE, PROCESS & COST REPORT

- IPD Comparison 2020
- Fan Out Packaging Comparison 2020

PATENT LANDSCAPE REPORT

- Fan-Out Wafer/Panel Level Packaging 2020

PHOTONICS

MARKET & TECHNOLOGY REPORT

- Quantum Technologies 2020
- LiDAR for Automotive and Industrial Applications 2020
- Silicon Photonics 2020
- Optical Transceivers for Data and Telecom 2020

PATENT LANDSCAPE REPORT

- Silicon Photonics and Photonic Integrated Circuits 2020

POWER ELECTRONICS

MARKET & TECHNOLOGY REPORT

- Power Electronics for Electric & Hybrid Electric Vehicles 2020
- Status of the Power Electronics Industry 2020
- Status of the Power Module Packaging Industry 2020
- Discrete Power Device Packaging: Materials Market and Technology Trends 2019
- Power Management IC: Technology, Industry and Trends 2019
- Status of the Inverter Industry 2019

STRUCTURE, PROCESS & COST REPORT

- Power Module Packaging Comparison 2020
- Si IGBT Comparison 2020
- Smartphone RF FEM Comparison 2020

PATENT LANDSCAPE REPORT

- Wide Band Gap Power Modules 2020

RF DEVICES & TECHNOLOGIES

MARKET & TECHNOLOGY REPORT

- 5G's Impact on RF Front-End for Telecom Infrastructure 2020
- 5G's Impact on RF Front-End Module and Connectivity for Consumer Applications 2020
- Status of the Radar Industry: Players, Applications and Technology Trends 2020
- Status of the Thin-Film Integrated Passive Devices 2020
- Active and Passive Antenna Systems for Telecom Infrastructure 2019

STRUCTURE, PROCESS & COST REPORT

- RF Modules for Connectivity Comparison (WiFi & Bluethooth & UWB) 2020
- mmWave Radars Comparison 2020
- Smartphone RF FEM Comparison 2020 (4 volumes)
- SAW Filters Comparison 2020

OUR 2020 REPORTS COLLECTION (4/4)

PATENT LANDSCAPE REPORT

- RF Acoustic Wave Filters 2019
- Antenna for 5G and 5G-related Applications 2019
- RF GaN 2019

SEMICONDUCTOR MANUFACTURING

MARKET & TECHNOLOGY REPORT

- Equipment and Materials for Thinning Semiconductor Substrates 2020
- Epitaxy Growth Equipment for More than Moore 2020
- Deposition (PVD + CVD + ALD + Thermal Oxidation): Equipment & Materials for MtM Devices 2020
- Glass Substrate for Semiconductor and Displays at the Wafer and Panel Levels 2020
- Laser Manufacturing for Front End, Back End & Substrates 2020
- Small Dimension Wafers Market 2020
- Nano-Imprint Technology Trends for Semiconductor Applications 2019

PATENT LANDSCAPE REPORT

- Hybrid Bonding 2019

SENSING AND ACTUATING

MARKET & TECHNOLOGY REPORT

- BioMEMS 2020
- High-End Inertial Sensors 2020
- Point-of-Need Testing: Application of Microfluidic Technologies 2020
- Sensing and Computing for ADAS Vehicle 2020
- Sensing and Computing for Robotic Transportation 2020
- Status of the MEMS Industry 2020
- Status of the Microfluidics Industry: Techniques, Manufacturing and Materials 2020
- Ultrasound Technologies for Consumer, Medical and Industrial Markets 2020
- Wearables for Consumer and Medical Markets 2020
- Emerging Printing Technologies 2019
- Inkjet Printheads: Dispensing Technologies & Market Landscape 2019
- Next Generation Sequencing & DNA Synthesis: Technology, Consumables 2019
- Organs-On-Chips Market and Technology Landscape 2019
- Piezoelectric Devices: From Bulk to Thin-Film 2019
- Uncooled Infrared Imagers and Detectors 2019

STRUCTURE, PROCESS & COST REPORT

- Automotive Inertial Sensors Comparison 2020
- Consumer Magnetic Sensor Comparison 2020
- MEMS Microphones Processes Comparison 2020
- Mobile Inertial Sensors comparison 2020
- Piezoelectric Material From Bulk to Thin Film – Comparison 2019
- Particle Sensor Comparison 2019

PATENT LANDSCAPE REPORT

- Circulating Tumor Cells Isolation 2020
- LiDAR 2020
- MEMS Foundries IP Portfolio 2020
- MEMS Sensors & Actuators: 2019 IP Trends and Prospective
- Microneedles for Biomedical Applications 2020
- Piezo MEMS 2020
- Nanopore Sequencing 2019

OUR 2020 MONITORS COLLECTION (1/2)

MARKET MONITORS

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. Starting from Q4 2019

Application Processor – *NEW*

The monitor examines and forecasts the application processor segment. It tracks processor revenue, units, and wafer volumes at both fabless chip designers and at the foundries themselves, sliced across various relevant parameters including process node, end product segment, core and IP type, etc. The monitor also examines the reported financials of players within the ecosystem. Starting from Q4 2019.

Compound Semiconductors – *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. Starting from Q4 2019

CMOS Image Sensors – *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 ONSemiconductor will thus be analysed. Starting from Q3 2019

DRAM

This monitor analyzes the evolution of the DRAM market in terms of revenue, shipments, capex, and near-term price evolution, as well as demand per market segment (data centers, mobile, automotive, graphics, and PC), DRAM technology evolution, and detailed profiles of main suppliers. It also provides DRAM monthly pricing to track the price evolution of key components and packaged solutions.

NAND

This monitor provides all data related to NAND revenue per quarter, NAND shipments, pricing per NAND type, near and long-term revenue, market share per quarter, capex per company, and a market demand/ supply forecast, along with a complete analysis and details on the demand side, with a deep dive into client and enterprise SSD, data centers, mobile, automotive, PC, and more.

OUR 2020 MONITORS COLLECTION (2/2)

PATENT MONITORS

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 MMICs, packaging, modules and systems.

RF Acoustic Wave Filters

Including Surface Acoustic Wave (SAW), Temperature Compensated (TC)-SAW, Bulk Acoustic Wave- Free-standing Bulk Acoustic Resonator (BAWFBAR), BAWSolidly-Mounted Resonator (BAW-SMR), and Packaging.

Microfluidics

From components to chips and systems, including all applications.

Solid-State Li-ion Batteries

This monitoring service tracks patents related to 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.

REVERSE TECHNOLOGY MONITOR

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 monitor will provide the design wins for the top smartphones OEM, the packaging evolution in term of type, footprint, pitch, as well as die area evolution per function, technology node, wafer size. It will offer a clear view of the technological strategy of the semiconductor companies leading the market and a direct comparison between OEM.

OUR 160+ TRACKS

Access anytime via our web portal new teardowns and updates, as our analysis progresses

System Plus Consulting's teardown tracks uncover innovative design features and new semiconductor components to guide enterprises toward more streamlined solutions in future designs. We provide clients unmatched intelligence into 5 main tracks:

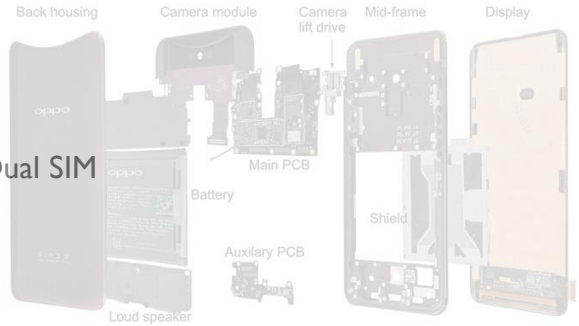
PHONES* - 440+ PRODUCTS ALREADY AVAILABLE

APPLE
- iPhone 11 Pro 512GB
- iPhone 11 Pro 256GB
- iPhone XR

OPPO
- OPPO Reno 5G
- OPPO K1
- OPPO R17 PRO

SAMSUNG
- Samsung Galaxy A50 64GB Dual SIM
- Samsung Galaxy Fold
- Samsung Galaxy Xcover 4s

XIAOMI
- Xiaomi Mi Mix 3 5G 64GB
- Xiaomi Black Shark 2 128GB 8GB RAM
- Xiaomi Redmi Note 7 Pro



SMART HOME* - 90+ PRODUCTS ALREADY AVAILABLE

AMAZON
- Amazon Show 5
- Amazon Echo plus (2nd gen.)

GOOGLE
- Google Home Hub
- Google Clips

WEARABLE* - 130+ PRODUCTS ALREADY AVAILABLE

APPLE
- Apple Airpods Pro w/Wireless charger
- Apple Watch 5

BOSE
- Bose Frames

FITBIT
- Fitbit Charge 3
- Fitbit Versa
- Fitbit Flyer

CONNECTED DEVICES* - 110+ PRODUCTS ALREADY AVAILABLE

MICROSOFT
- Microsoft Surface Go

SAMSUNG
- Samsung Tab S5e

VERIZON
- Verizon HUM x (Gen 1)

AUTOMOTIVE

First teardowns available from Q1 2020 (60+ in 2020)

Non-contractual photos

I-MICRONEWS MEDIA

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	ONSITE	INPERSON
i-Micronews e-newsletter *i-Micronews.com* *FreeFullPDF.com*	*Events*	*Webcasts*
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.	**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.	**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.
#15,100+ monthly unique visitors on i-Micronews.com *#10,900+ weekly readers of i-Micronews e-newsletter*	*#110 attendees on average* *#14+ key events planned for 2020 on different topics*	*#280 registrants per webcast on average to gain new leads for your business*

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