



SEMI and Yole Développement Present: Smart Automotive – Latest Trends in LiDAR and Sensors

Bettina Weiss
Vice President, Business Development
SEMI Global Headquarters



SEMI Connects to Advance the Global Industry

Mission

SEMI provides industry stewardship and engages our members to advance the interests of the **global electronics manufacturing supply chain**.

Vision

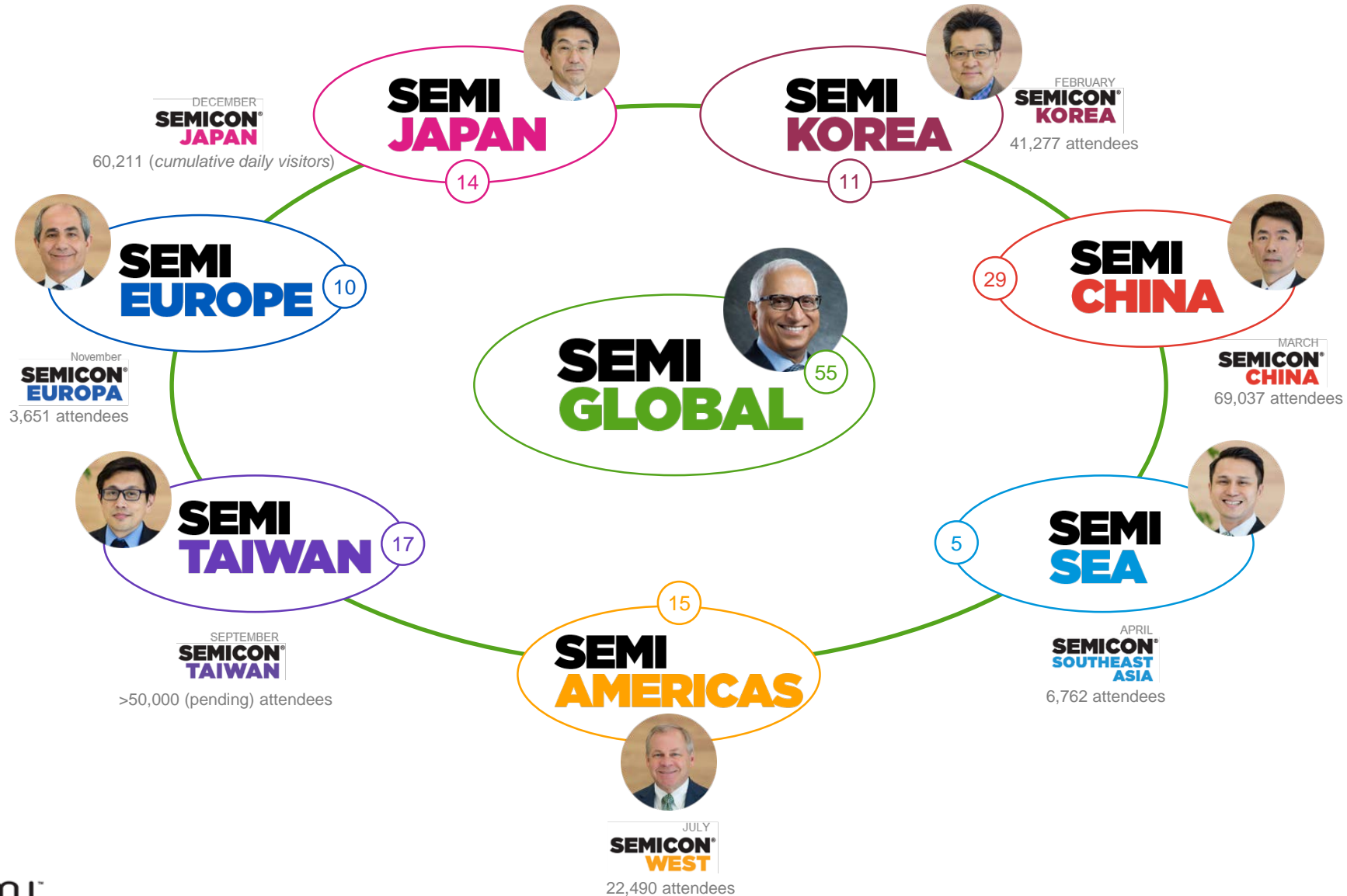
SEMI promotes the development of the global *manufacturing* electronics supply chain and positively influences the **growth and prosperity of its members**. SEMI advances the mutual business interests of its membership and promotes a free and open global marketplace.

SEMI is the place to connect, collaborate, innovate and solve problems in a pre/non-competitive forum. Platforms for regions and special interest groups are connected to global common interests.



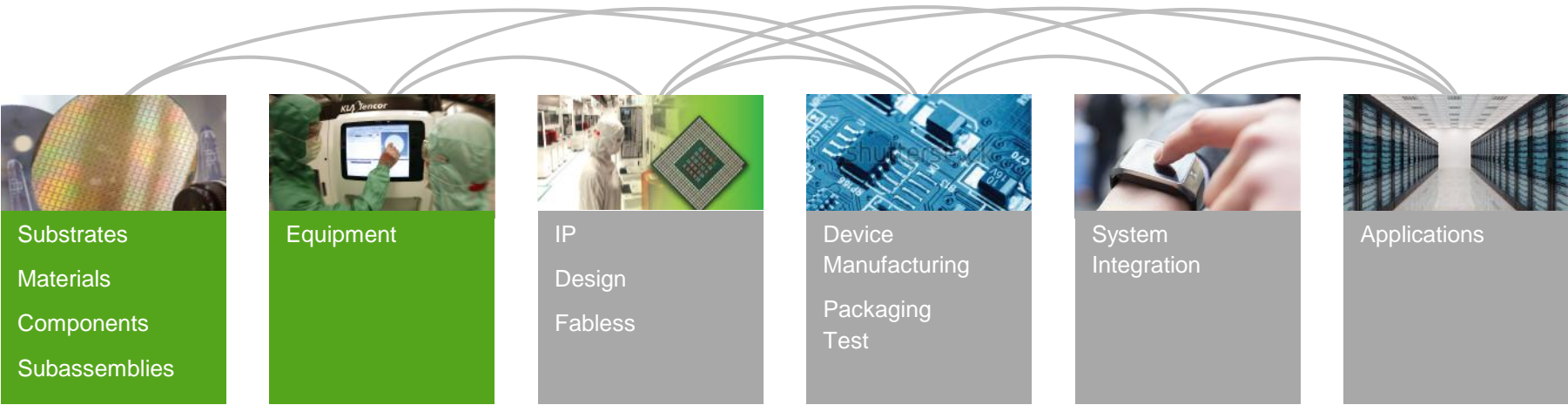
SEMI Global Platforms and Regional SEMICONS

Standards | Market Intelligence | Advocacy/Workforce Development | Communities | Programs | Expositions



- SEMI Members**
 - 1,270,000+ individual members
 - 2,086 member companies
- SEMI Standards**
 - 970 Standards
 - >5,128 volunteers
- SEMI Programs**
 - 170 programs
 - >27,000 attendees
 - >2,300 hours
- SEMI Special Interest Groups (SIGs)**
 - 13 SIGs
 - >1,850 members
- SEMI Expositions**
 - 322,076 attendees
 - 7 SEMICON expos
 - 4 specialty expos
 - 4,068 exhibitors

SEMI Connects the Electronics *Manufacturing* Supply Chain for Collaboration



Collaboration segments



Smart Transportation Application Vertical

The **SEMI Smart Transportation Initiative** connects SEMI members to customers, markets and product applications in a global supply chain

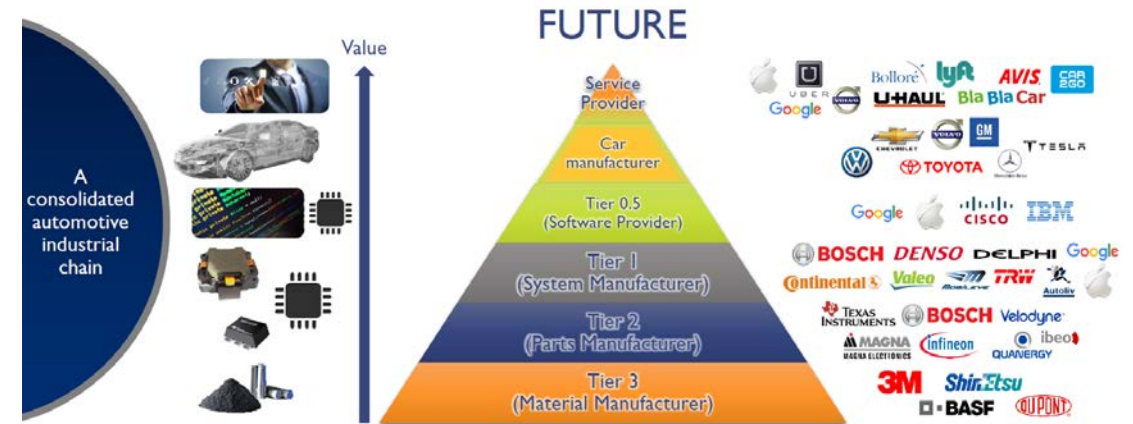
Why?

- Fast growing segment with >15% CAGR in 2016
- Consumes >10% of global IC production, and growing
- Global impact, but localized supply chains
- Shared challenges, SEMI members engaged
- Significant play for MEMS, sensors, power devices and opportunities for roadmaps, Standards, supply chain coordination

Objectives

- Connect members' core competencies to automotive supply chain for better business results
- Facilitate OEM-Tier 1/2 dialogue on shared technology and business issues
- Leverage interest and pain points related to Big Data, data analytics, security and safety in both communities and create collective solutions

INDUSTRIAL CHAIN FOR AUTOMOTIVE



Source: Yole Développement

Smart Transportation Vertical Application – Supply Chain Engagement

- **Strategic partnership with SAE International** for joint events

- Connect2Car @ SEMICON Europa `17;
- SEMI pavilion @ SAE World Congress Experience WCX, April `18)



- Co-organizing Georgia Tech **FUTURECAR event** (November 8-10, 2017, Atlanta)

- Technology-focused event highlighting developments in connected/autonomous vehicles, ADAS, LiDAR and related sensors and power capabilities; speakers from Porsche, Daimler, Bosch, GLOBALFOUNDRIES



- Smart Automotive tracks at **SEMICON expositions**

- SEMICON Europa 2017
- SEMICON Japan 2017



- Partnership with **Yole Développement** on automotive sensor and power device market coverage

- Member-only data access, webinars, presentations



- Assessing requirements for **Standards development**, regulatory and advocacy efforts

- Regional **Smart Automotive Advisory Committees** in formation

- OEM and Tier 1 stakeholder survey under way to determine shared challenges and technology/supply chain inflection points

Engagement opportunities:

- **Connect** to new supply chain stakeholders & customers
- **Access** to customers' customers.
- **Guide** developments of new industry Standards
- Strengthen collective supplier voice on regulatory issues
- **Get exposure** through speaking opportunities at Smart Automotive events

European Connect2Car Forum



Date: 16 November 2017
Time: 08:00–17:30
Location: ICM Munich, Room 14a (Germany)

First time at SEMICON Europa. Top speakers from the entire Automotive ecosystem provide valuable insights on technologies for connected/autonomous vehicles from semiconductors to:

- Data collection and sensing technology (LIDAR, RADAR, video)
- Networks (DSRC and 5G) to software
- Integration and cyber security concerns and solutions

Meet high-level industry leaders from HARMAN, Visteon, Volkswagen, Windriver and more.

Registration under: www.semiconeuropa.org/european-connect2car-forum

Our First Speaker



Latest trends in LiDAR and Automotive Sensors

Guillaume Girardin works as a Market & Technology Analyst for MEMS devices and technologies at Yole Développement, the "More than Moore" market research and strategy consulting company. Guillaume holds a Ph.D. in Physics and Nanotechnology from Claude Bernard University Lyon 1 and a M.Sc. in Technology and Innovation Management from EM Lyon School of Business.

Smart Automotive

Latest trends in LiDAR
and innovative sensors

- Presentation of Yole Développement
- Automotive market and autonomous trends
- Current market overview
- Focus on “hot” sensors
 - Night vision
 - Radar
 - Camera
 - LiDAR



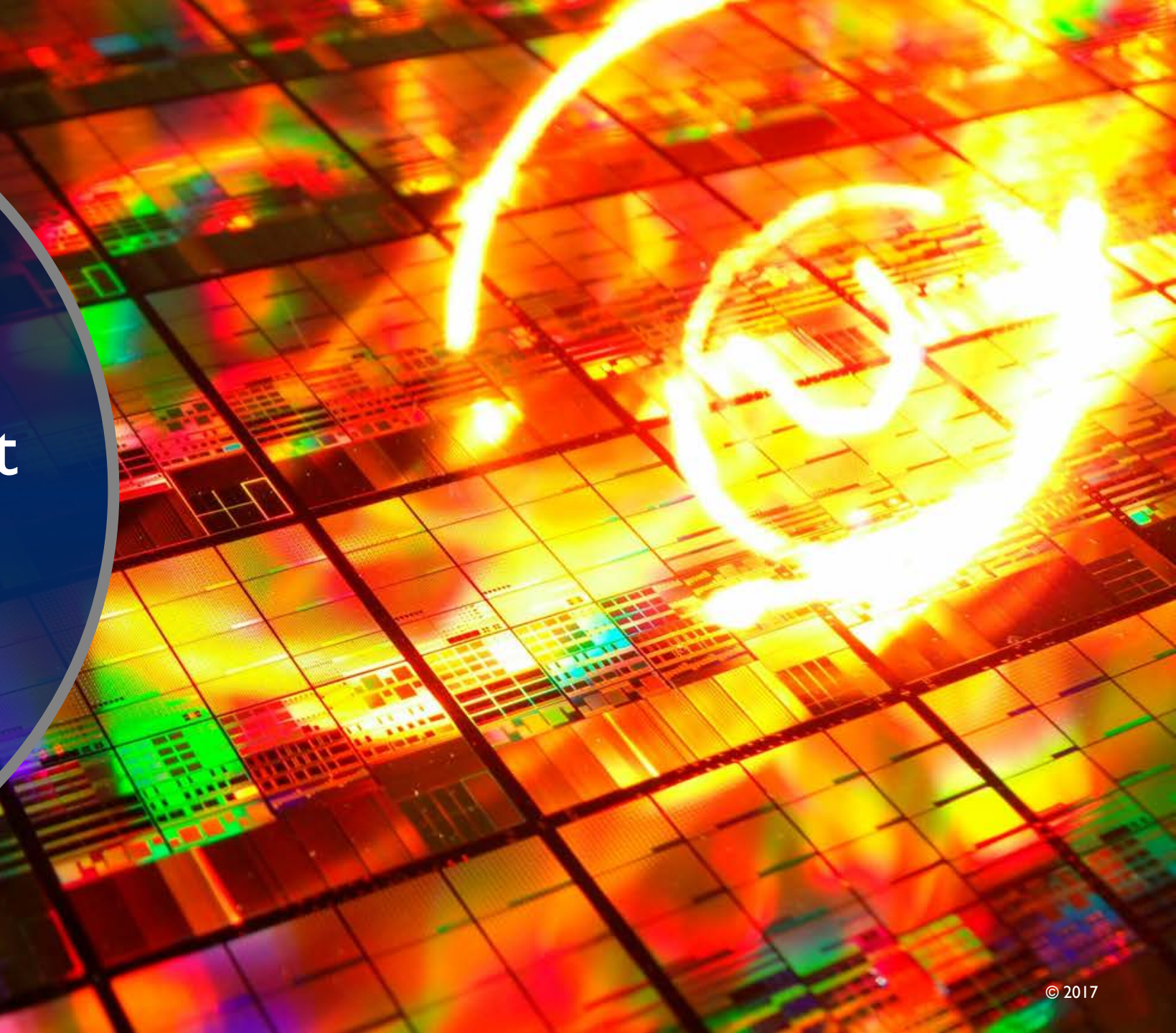
- Presentation of System Plus Consulting
- Analysis of teardowns
 - Forward camera – TRW, Bosch and Continental
 - LiDAR – Leddartech, Continental laser ranger





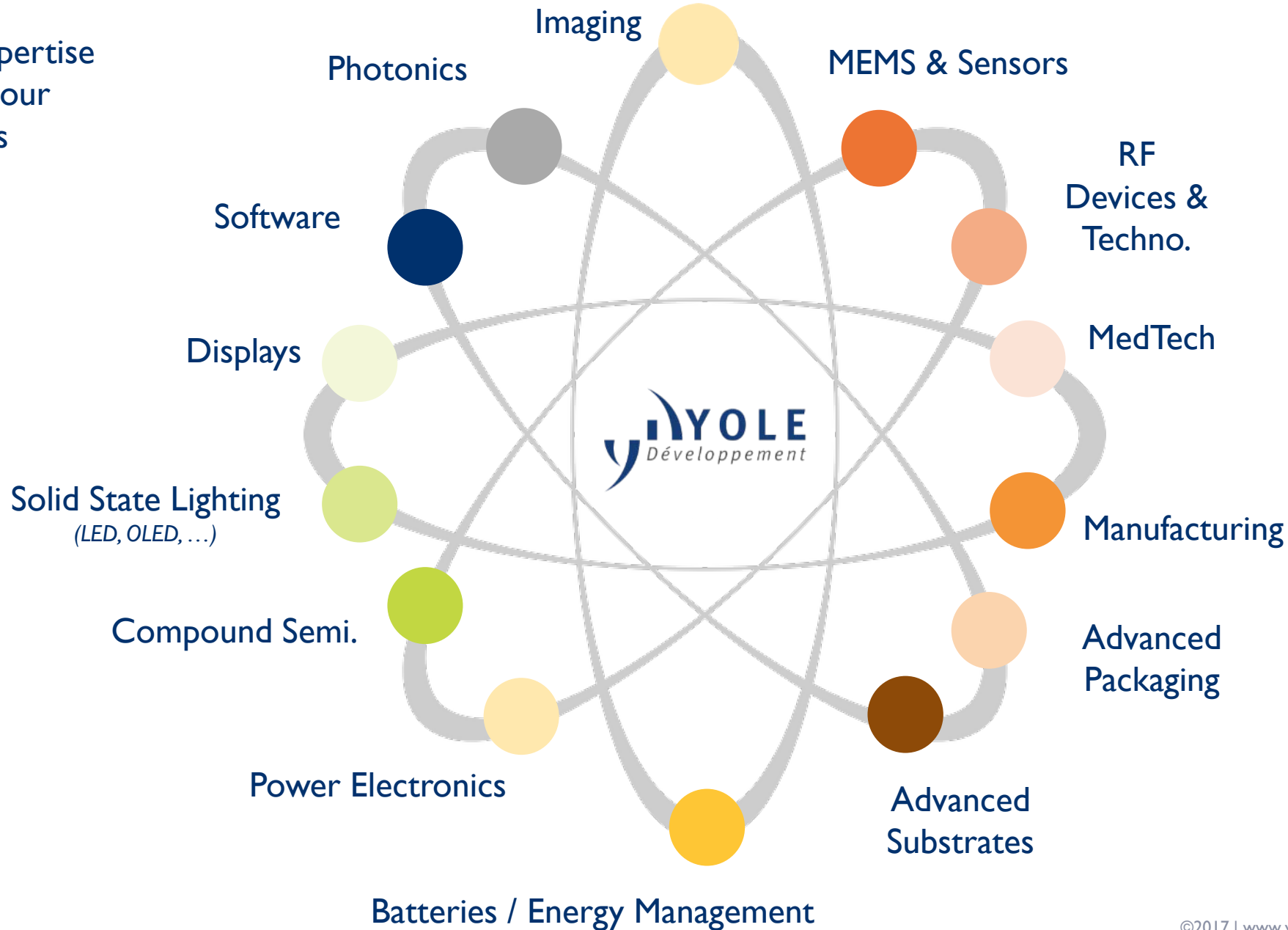
Yole Développement

From Technologies to Market





Fields of expertise covered by our 35+ analysts



A GROUP OF COMPANIES



Market, technology
and strategy
consulting

www.yole.fr



Due diligence

www.yole.fr



Innovation and business maker

www.bmorpho.com



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



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



Reports

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



www.i-Micronews.com/reports



Media

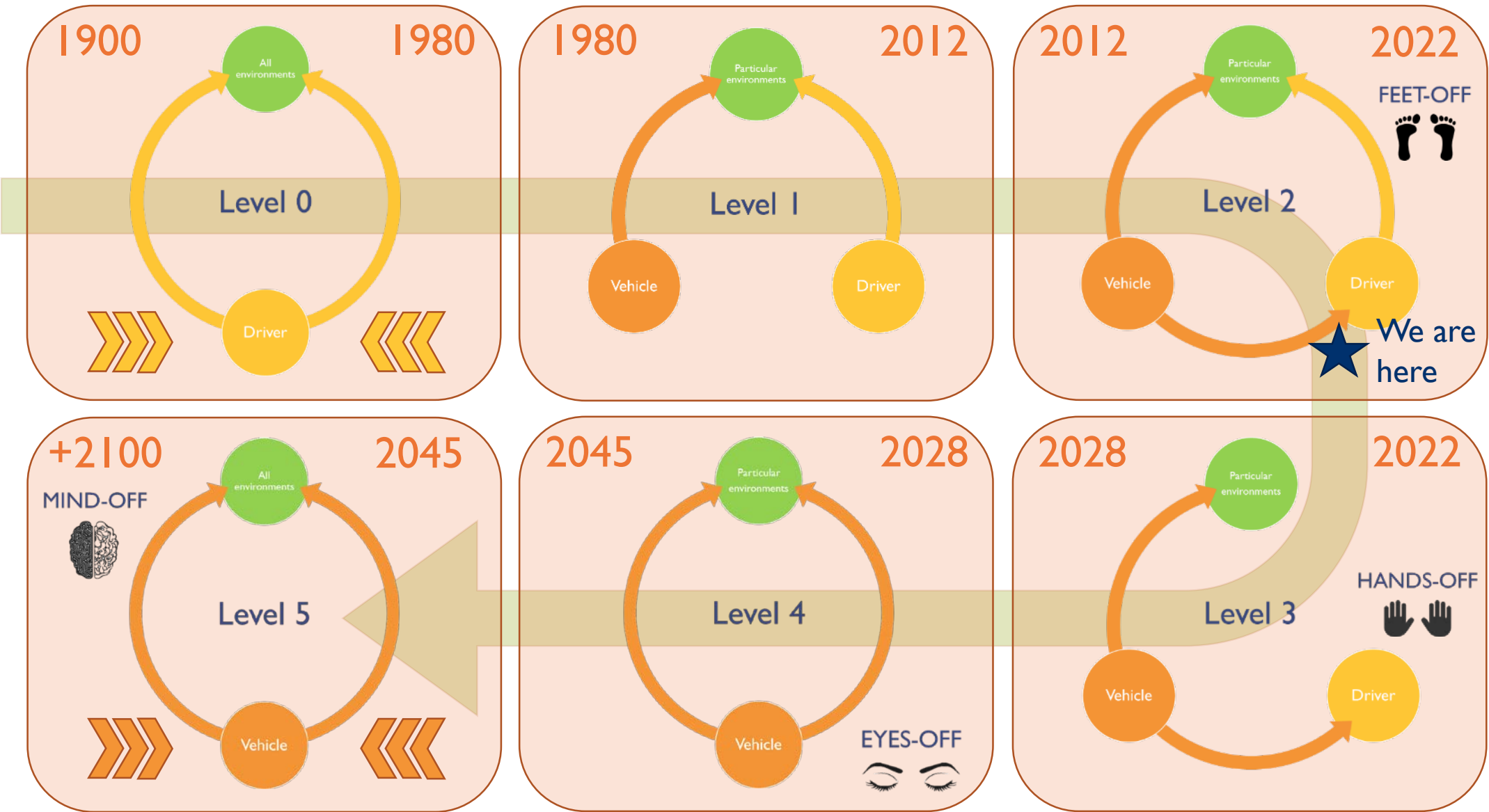
- i-Micronews.com website
- @Micronews e-newsletter
- Communication & webcast services
- Events: TechDays, forums,...

www.i-Micronews.com

THE VEHICLE SLOWLY REPLACES THE DRIVER



Replacing the driver in high-end automotive should take around 150 years

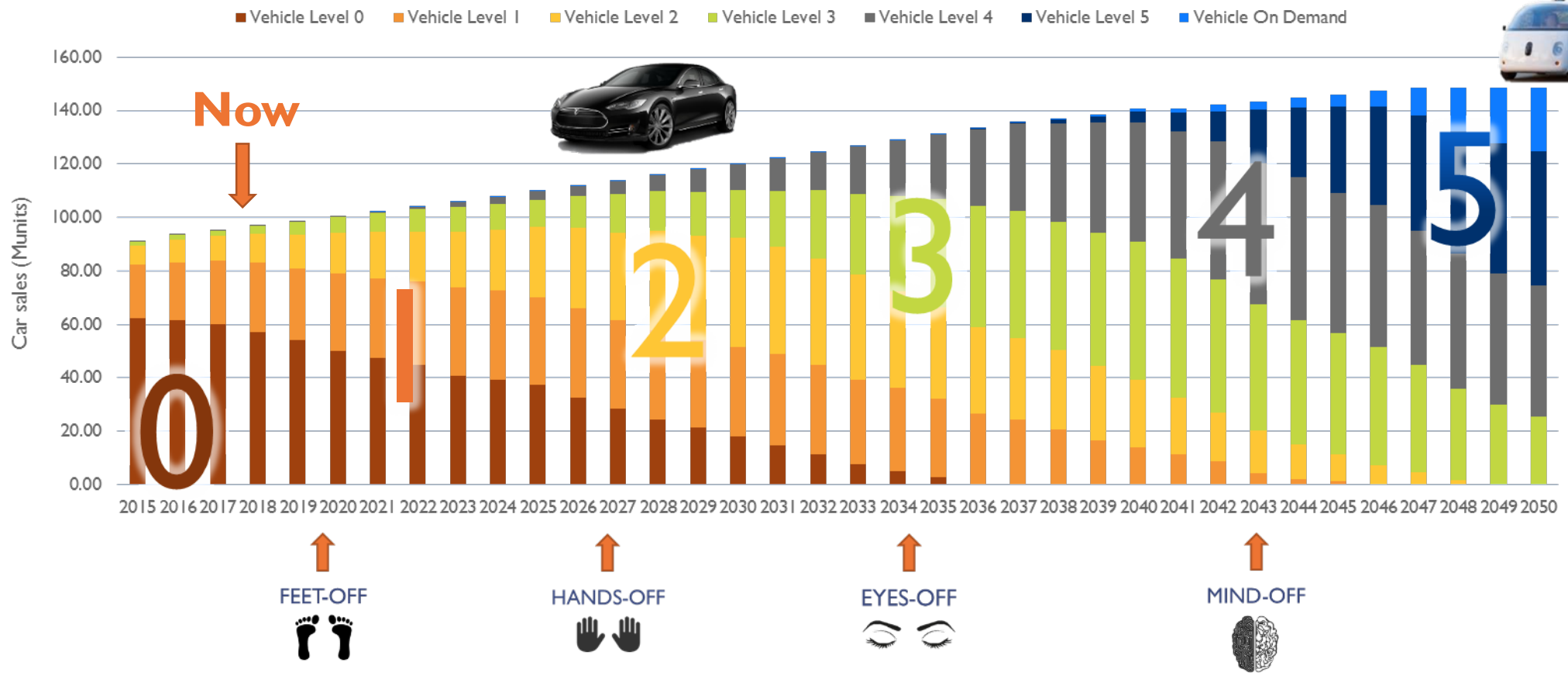


THE DEATH OF DRIVING



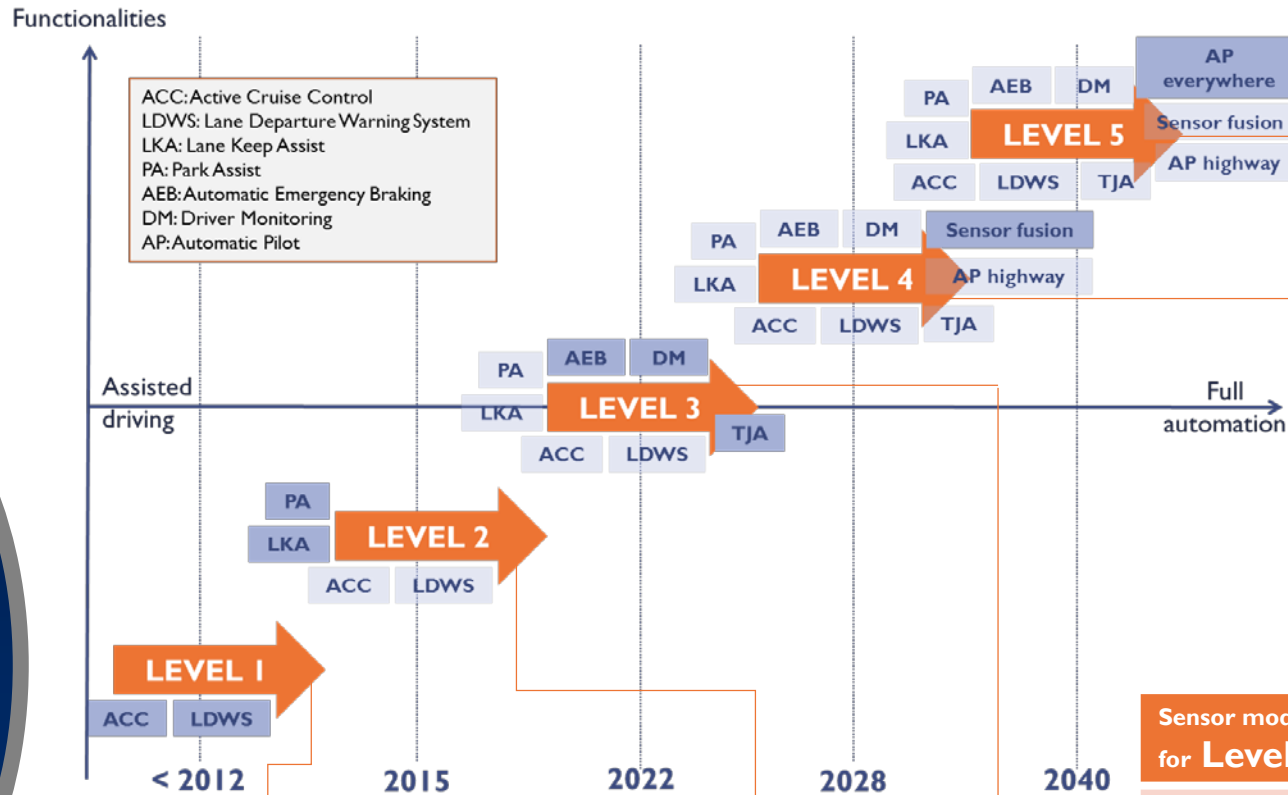
By 2050, 5% of all vehicles sold should be Level 5-ready!

Potential evolution of autonomous car sales by level of automation



By 2035, more than 50% of all vehicles sold will show level 3 capabilities!

SENSOR MODULE ASP FOR EACH AUTOMATION LEVEL



A level-3 car will have \$2,500 worth of embedded sensors for AD

Sensor modules for Level 1	#	ASP/u (\$)
Ultrasonic	6	\$15
Radar LRR	1	\$140
Forward camera	1	\$40
Backup camera	1	\$30
TOTAL	9	\$300

Sensor modules for Level 2	#	ASP/u (\$)
Ultrasonic	8	\$15
Radar LRR	1	\$135
Forward camera	3	\$30
Camera surround	4	\$25
TOTAL	16	\$445

Sensor modules for Level 3	#	ASP/u (\$)
Ultrasonic	8	\$14
Radar LRR	1	\$105
Radar SRR	4	\$43
Forward camera	3	\$27
Driver cam	1	\$20
Camera surround	4	\$20
μbolometer	0	\$390
LIDAR	1	\$1,500
Dead reckoning	0	\$400
TOTAL	22	\$2,070

Sensor modules for Level 5	#	ASP/u (\$)
Ultrasonic	8	\$11
Radar LRR	1	\$63
Radar SRR	4	\$31
Forward camera	3	\$20
In-cabin/Driver cam	1	\$25
Camera surround	4	\$12
Event-based camera	1	\$60
μbolometer	1	\$190
LIDAR	4	\$200
Dead reckoning	1	\$300
TOTAL	28	\$1,758

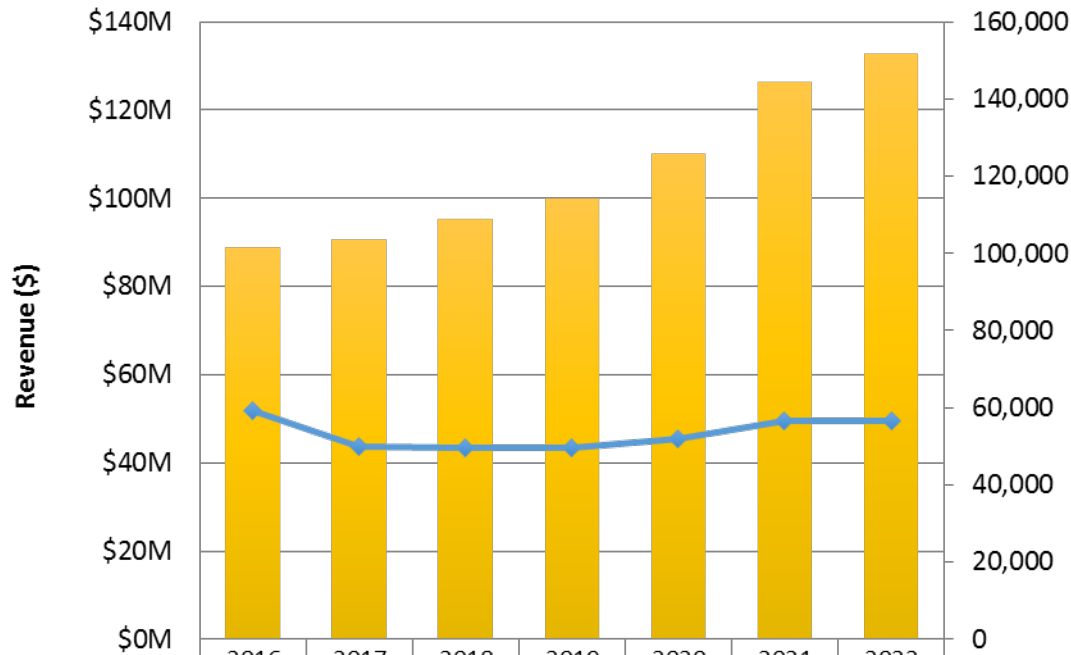
Sensor modules for Level 4	#	ASP/u (\$)
Ultrasonic	8	\$13
Radar LRR	1	\$70
Radar SRR	4	\$35
Forward camera	3	\$24
In-cabin/Driver cam	1	\$30
Camera surround	4	\$15
Event-based camera	1	\$90
μbolometer	1	\$290
LIDAR	2	\$350
Dead reckoning	1	\$350
TOTAL	26	\$1,906

FOCUS ON AUTOMOTIVE NIGHT VISION

We have considered a scenario where autonomous driving will boost sales, after 2025.

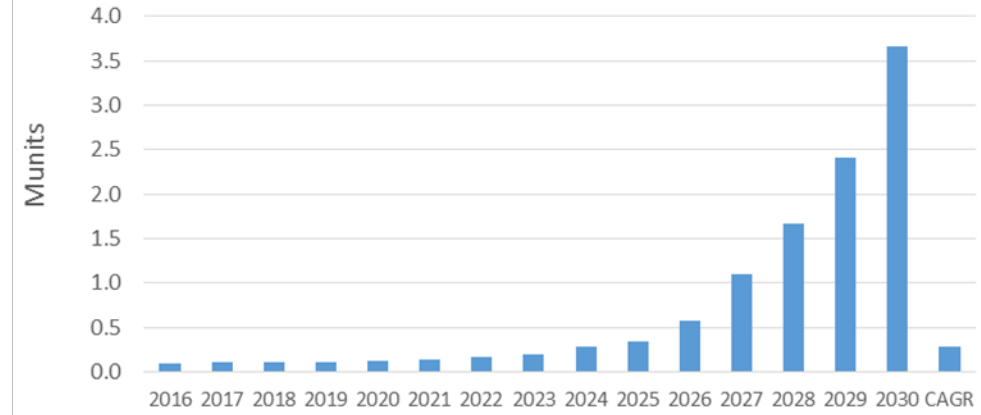
With modest volume growth and pressure to reduce prices, revenues are levelling off for automotive night vision applications.

2016-2022 automotive night vision market forecast, in \$ and units

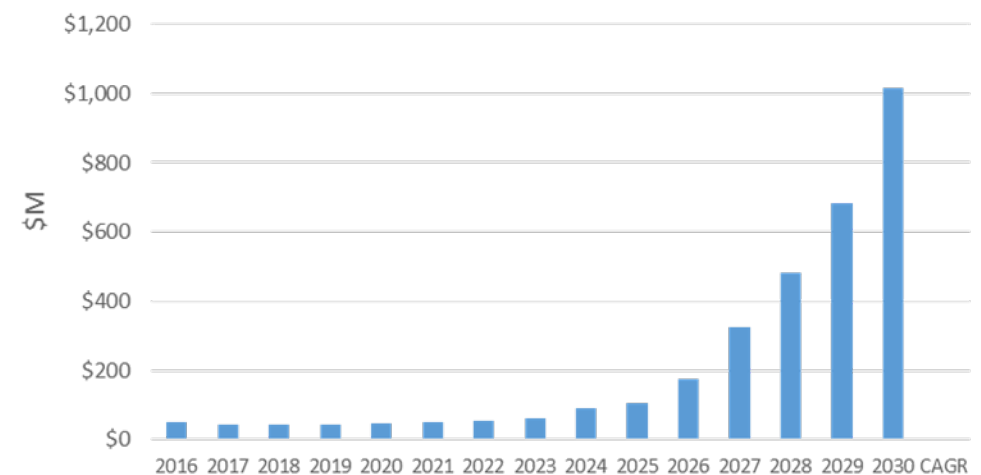


Automotive shipments	101,589	103,621	108,802	114,242	125,667	144,517	151,742
Automotive revenues	\$52M	\$44M	\$44M	\$43M	\$45M	\$50M	\$49M

2016-2022 microbolometers for autonomous cars and night vision market volume forecast in Munits



2016-2022 microbolometers for autonomous cars and night vision market revenue forecast in \$M

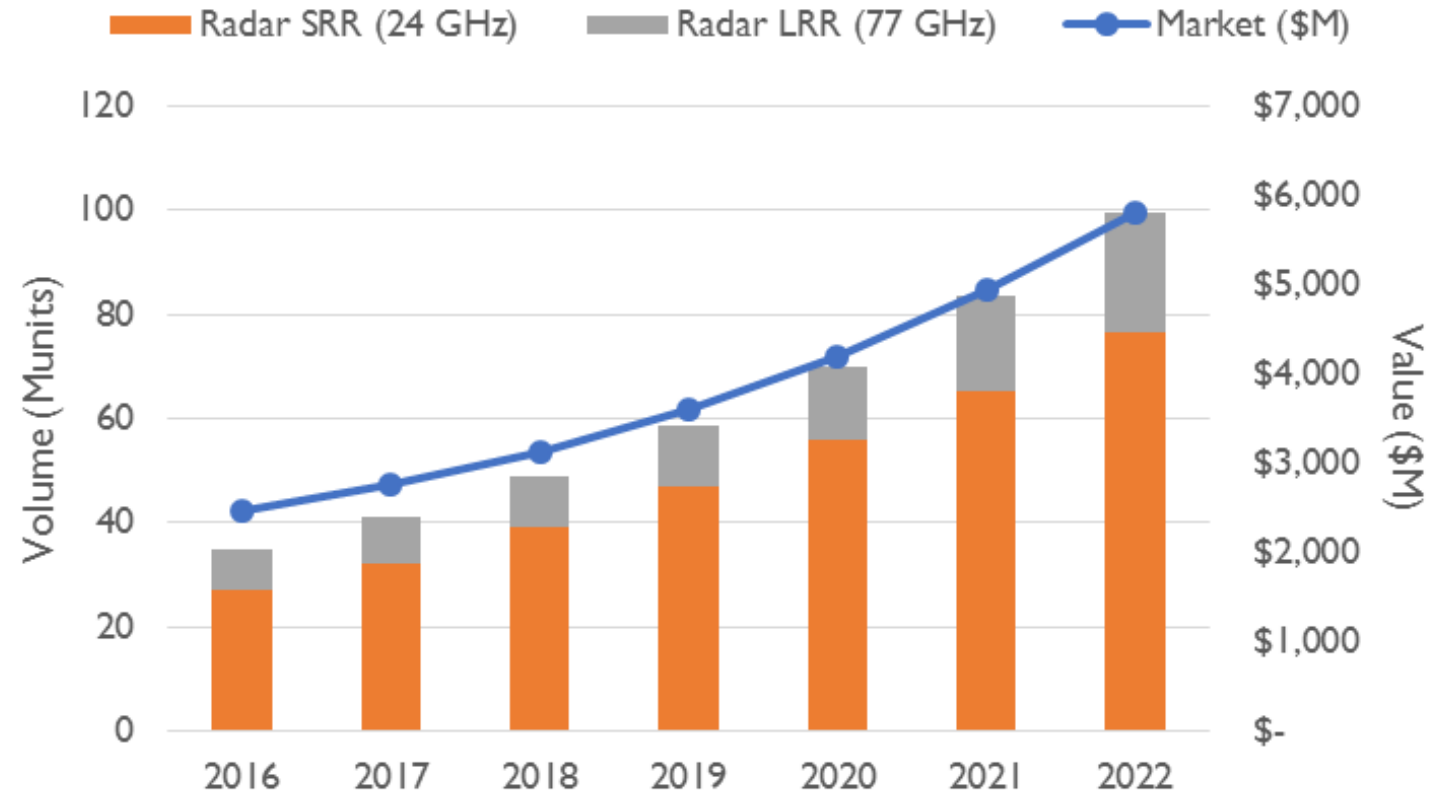




100Mu of radar per year by 2022?

- Short and long-range radars should take off in the coming years. With the arrival of ADAS functionalities requiring a high level of detection, a combination of imaging sensors and radar is mandatory.
- Imaging and radar shipments should increase at the same pace

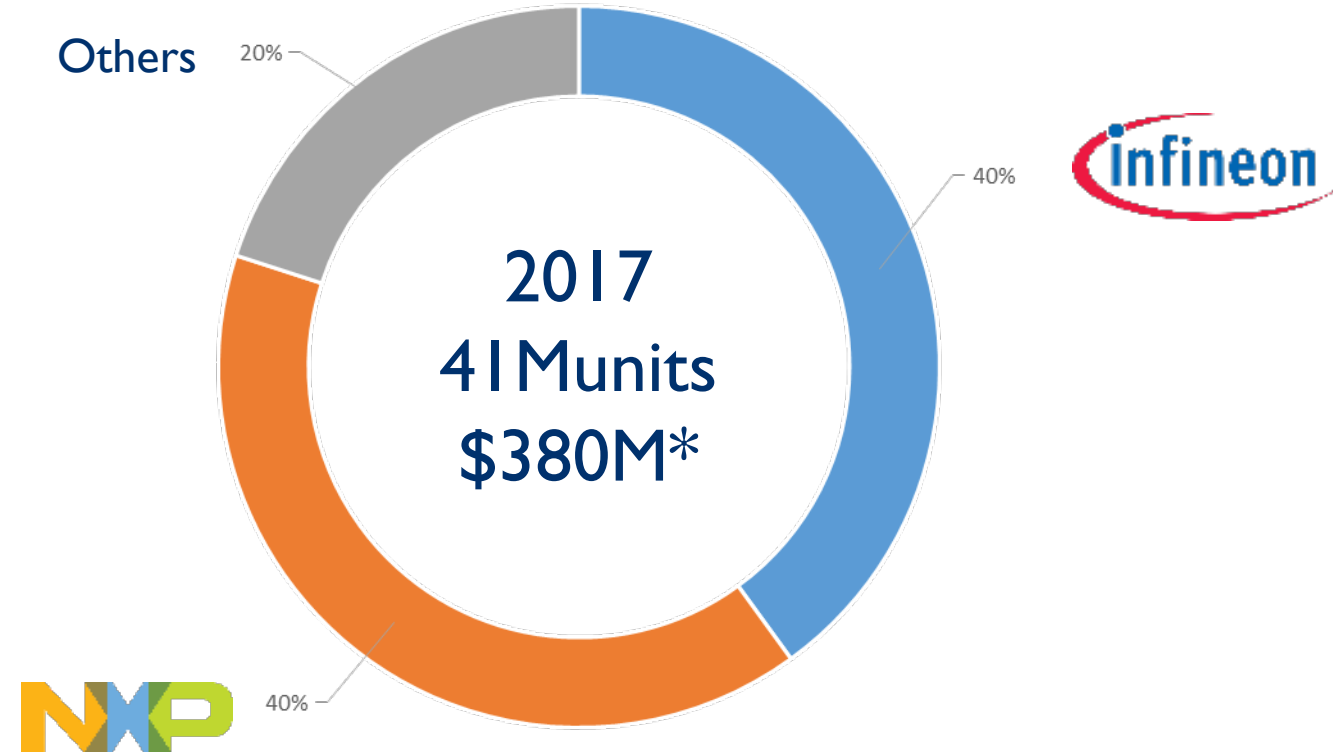
RADAR sensors market volume and global value - Munits & \$M





Infinion and NXP share the lead in this area

Automotive RADAR sensors - Market share



*Emitter/receiver chips for radar. Global radar modules' value: \$2.5B.

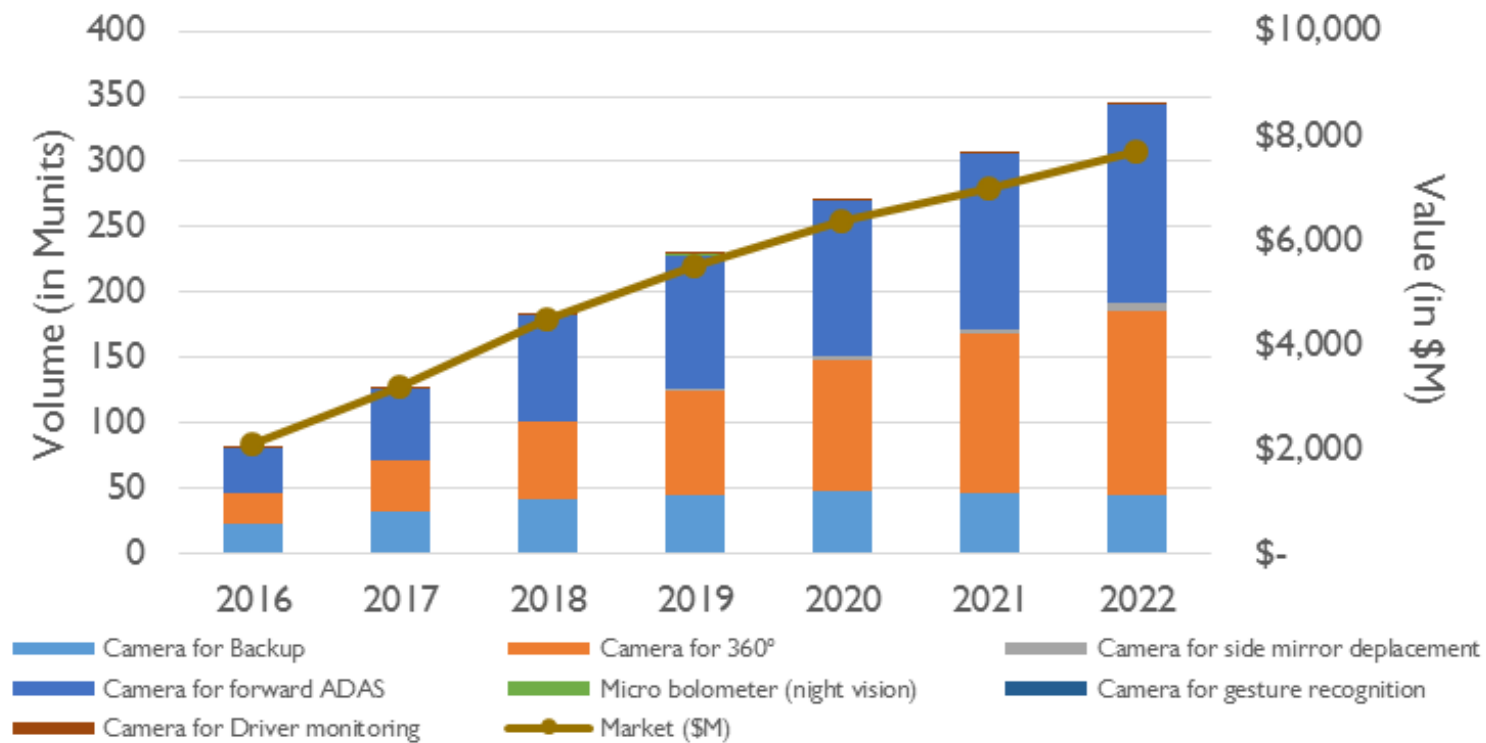
IMAGING SENSOR MARKET - VOLUME AND VALUE



The two main market drivers are IR diode (rain detection) and rearview camera

- Micro bolometer evolution: cf. trends part
- The two main market drivers are forward cameras for ADAS and 360° cameras
- Global market value has a 24% CAGR₂₀₁₆₋₂₀₂₂

Imaging sensors market volume and global value - Munits and \$M



IMAGING SENSOR - MAIN PLAYERS



ON Semi leads with more than 1/3 of the total market

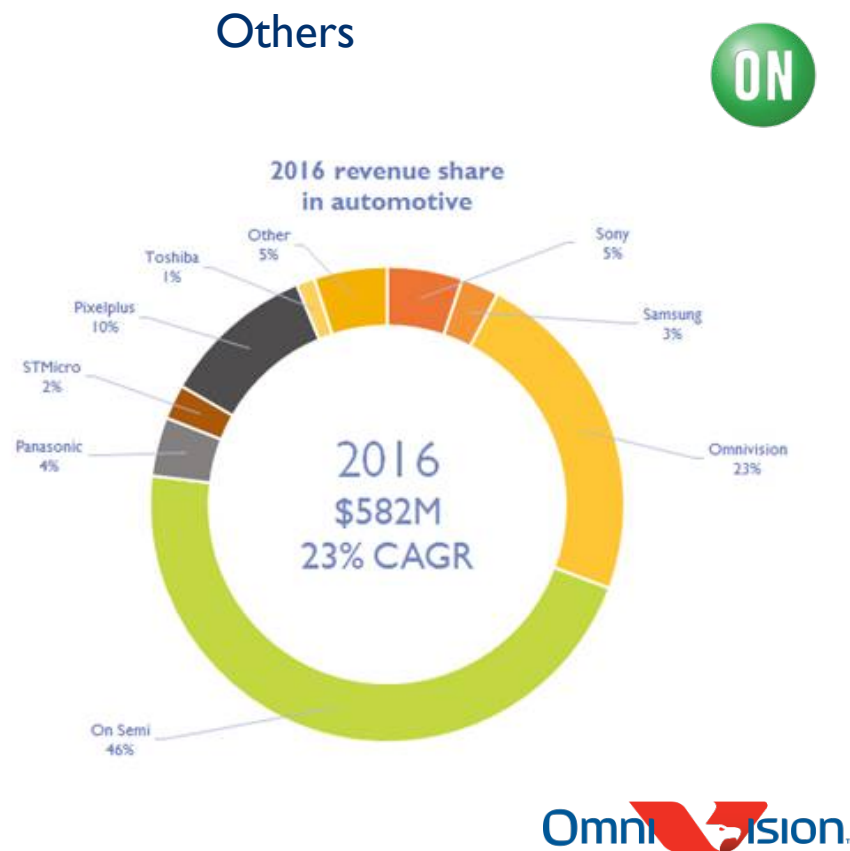
Melexis
INSPIRED ENGINEERING

SONY

TOSHIBA

PIXELPLUS

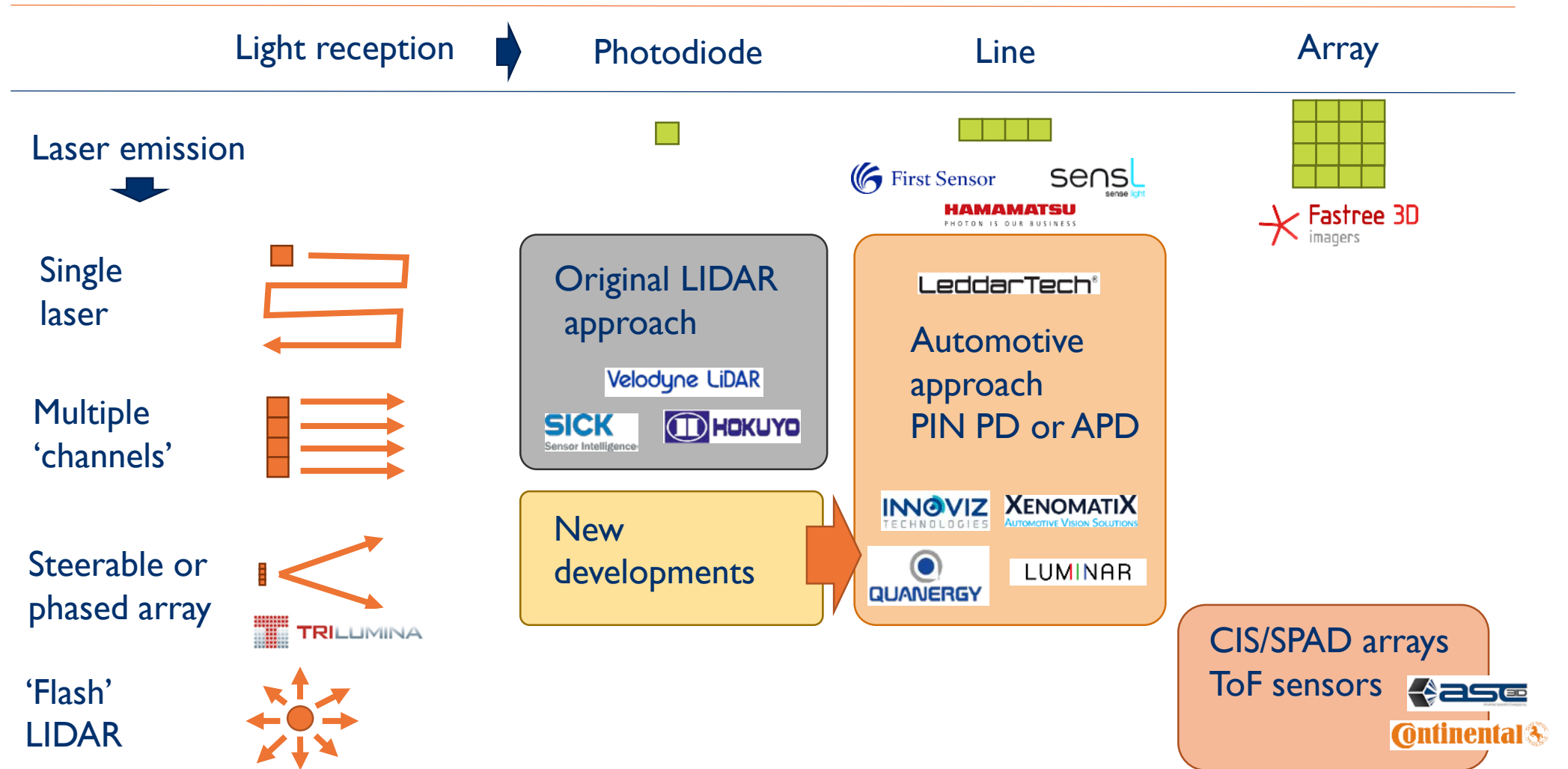
Panasonic



SOLID STATE LIGHT DETECTION AND RANGING

From single element to arrays

Different approaches are being explored.

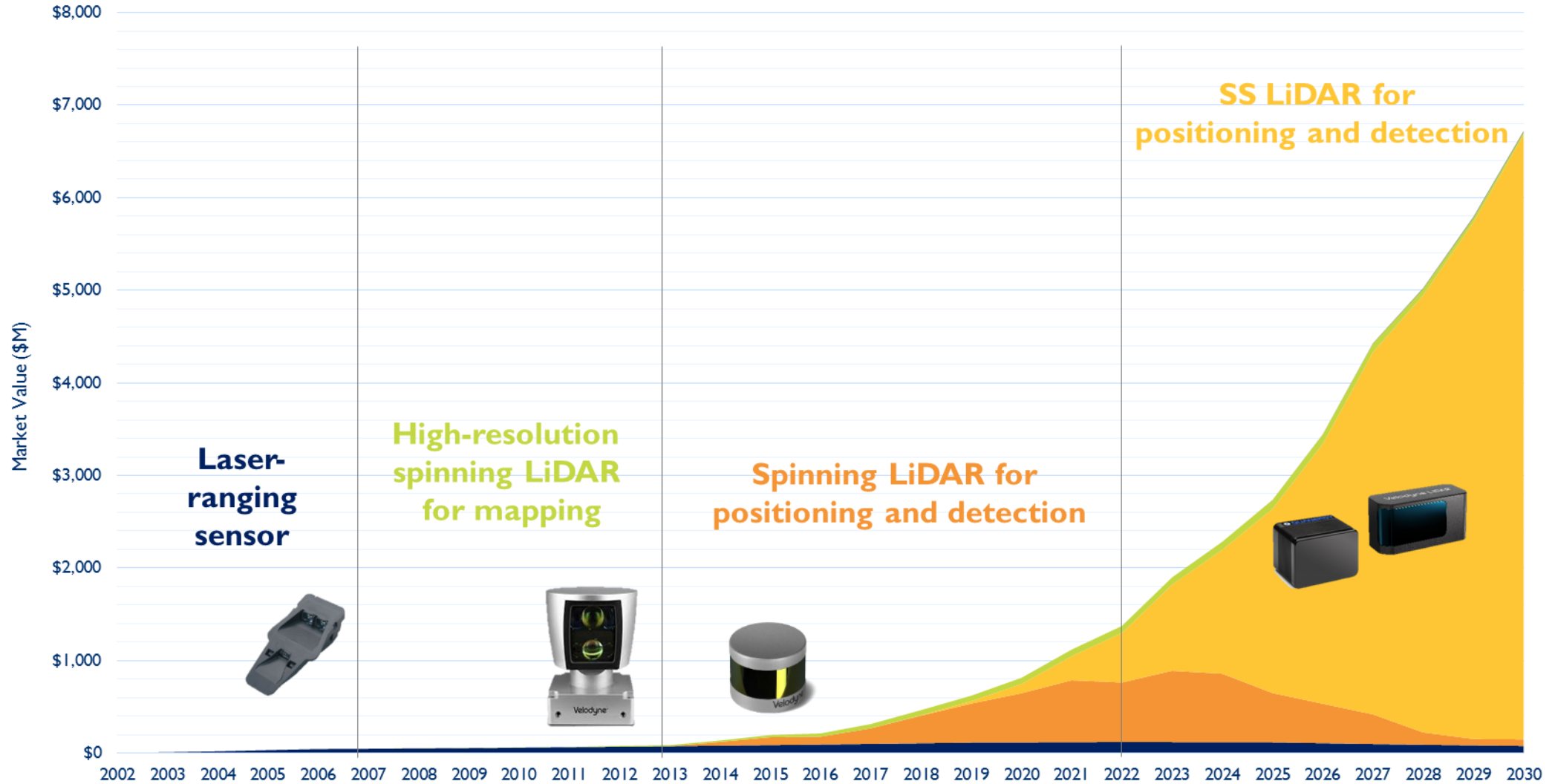


LIDAR MARKET (1/3)



The huge LiDAR market is emerging right now. Market value is expected to exceed US\$7B by 2030.

Evolution of the LiDAR technology market value in automotive - (\$M)



MULTIPLE APPLICATIONS AND MARKETS



Applications:

Laser ranging for AEB



Volume @2017: 2.2Mu
Volume @2027: 3Mu



1D laser ranger

Moving toward

AEB will merge with standard ADAS feature. Currently, the AEB market is dominated by radar. Future AEB feature powered by radar and upcoming LiDAR?

Positioning and detection for level-3 car



Volume @2017: 20Ku
Volume @2027: 10Mu



Mechanical/Spinning/MEMS LiDAR

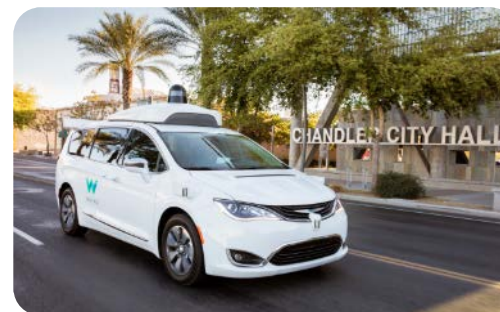
Moving toward

Phased array + Si SPAD 905nm



Solid-state silicon-based LiDAR

Positioning and detection for robotic car



Volume @2017: 10Ku
Volume @2027: 100Ku



Mechanical/Spinning/MEMS LiDAR

Moving toward

Phased array + Si SPAD 905nm
MEMS mirror + Si or GaAs APD or SPAD



Solid-state silicon-based LiDAR

World digitalization



Volume @2017: 700u
Volume @2027: 3,500u



Velodyne

Moving toward

MEMS mirrors + GaAs APD



Velodyne

Market segmentation is quite difficult

BIG PICTURE OF LIDAR MARKET OPPORTUNITIES TIMELINE



2017

LiDAR cost

\$5000

The LiDAR market is a significant market just starting, but first real implementation should not be where most people think. Due to high cost of manufacturing, LiDAR ASP will remain high for some years, therefore ROI matters, only commercial applications will have an interest in this technology to save driver's cost (i.e. taxis, trucks, buses...)

LiDAR Market size

\$300M

LiDAR for Robotic vehicle

- Public Pod Transport
- Agriculture
- R&D



LiDAR for Robotized vehicle

- Commercial/Goods Transport (Convoy)
- On-demand Taxis (L5)



Emerging Technology (Start-ups)

Full-scale Implementation (Large groups/New ventures)

Pervasive Technology (Large Automotive groups)

2022

LiDAR Market size

\$1.4B

LiDAR cost

\$1500

LiDAR for Autonomous Individual Transport

- Personal vehicle (L4/L5)

LiDAR Market size

\$4.4B

LiDAR cost

\$500



2027

COMPLEMENTING TECHNOLOGIES

LiDAR with cameras with RADARs



These three technologies are market rivals, but complementary in a car

	LiDAR	Radar	Cameras
Sensing Dimensions	3D	1D	2D
Range (in m)	100m	250m	100m
Field of View (in °)	From 100° to 120°	From 20° to 70°	From 50° to 150°
Volume (in cm ³)	9x6x6 cm ³	8x8x6 cm ³	8x7x3 cm ³
3D Shape	++	-	+
Accuracy (in cm)	±5cm	±120cm	±15cm
Rain, Snow, and Dust	++	+++	-
Fog	+	+++	-
Pitch Darkness	+++	+++	+
Bright Sunlight	++	+++	++ (HDR)
Ambient Light Independence	+++	+++	++ (HDR)
Read Signs & See Colors	-	-	+++
2020 ASP (in \$)	\$1500 - 2000	\$80 - 100	\$90
Main function	Pedestrian protection	Collision avoidance, cruise control	Sign reading, texture analysis



LiDAR (Velodyne)

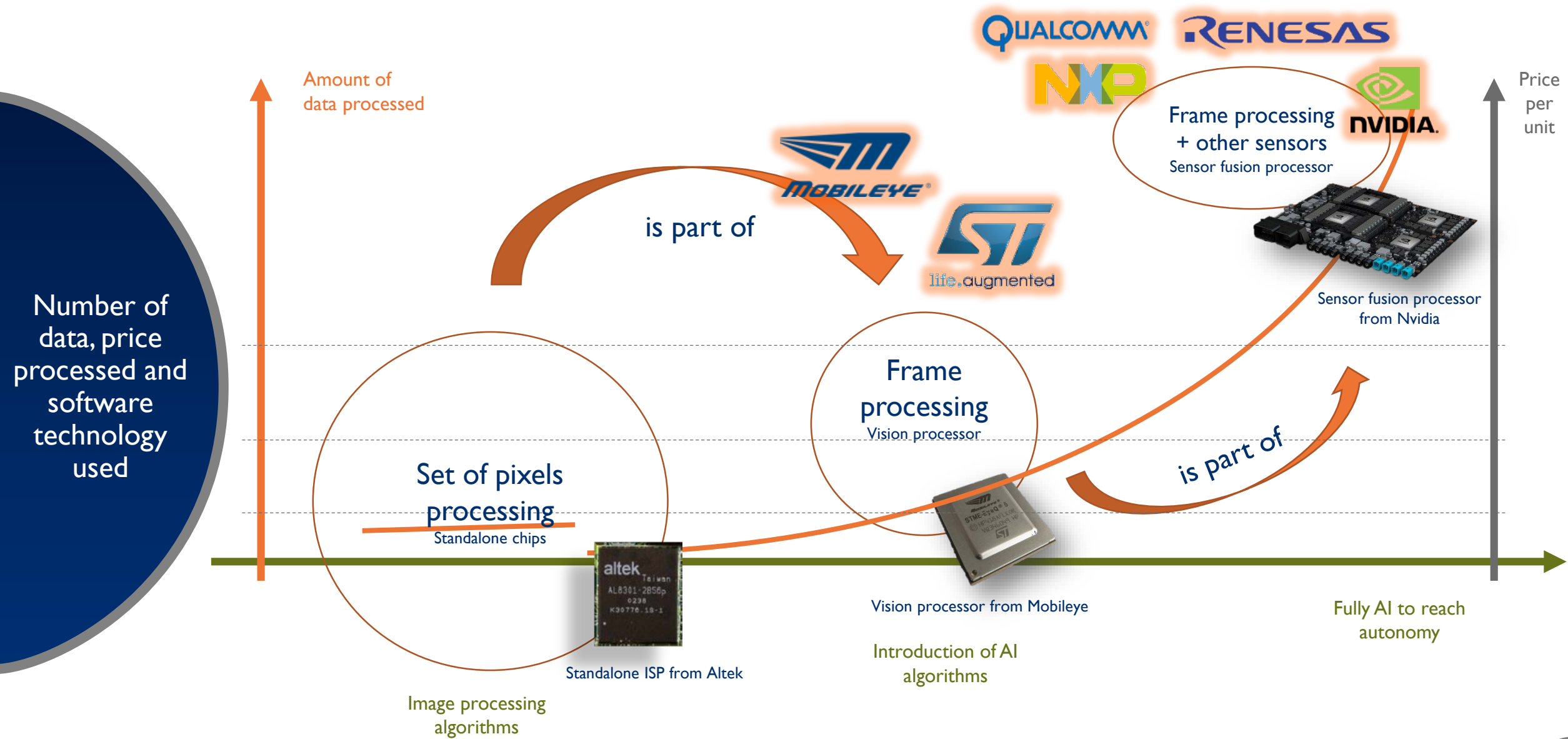


Long-range radar (BOSCH)



ADAS camera (TRW)

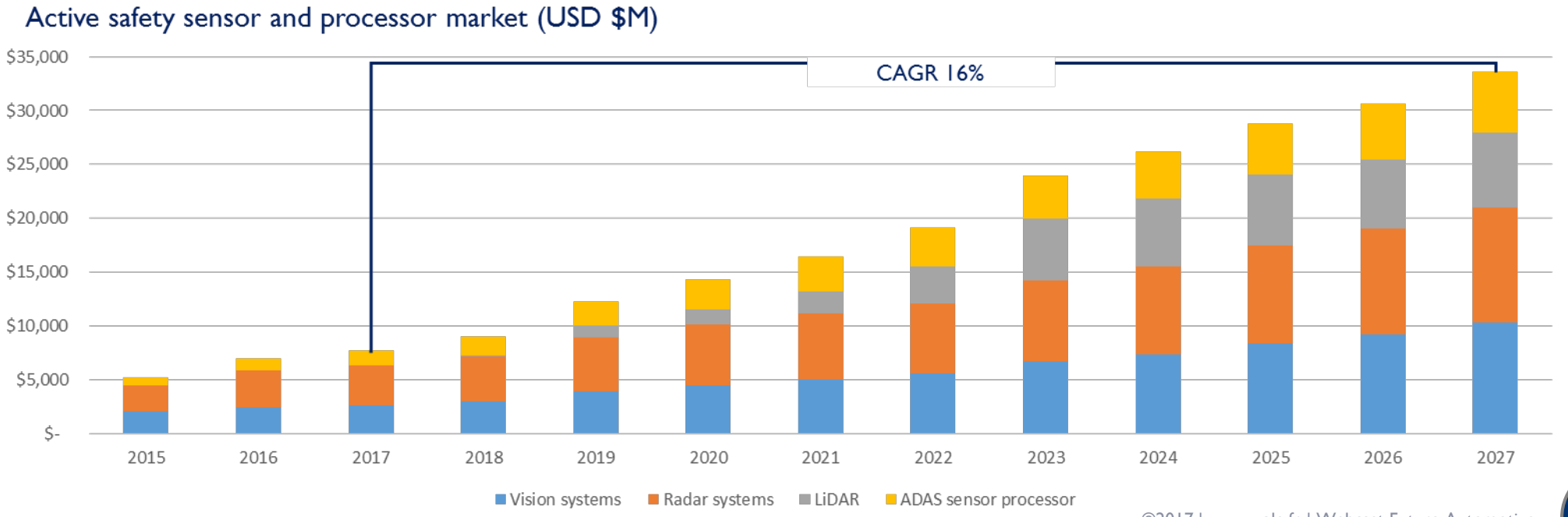
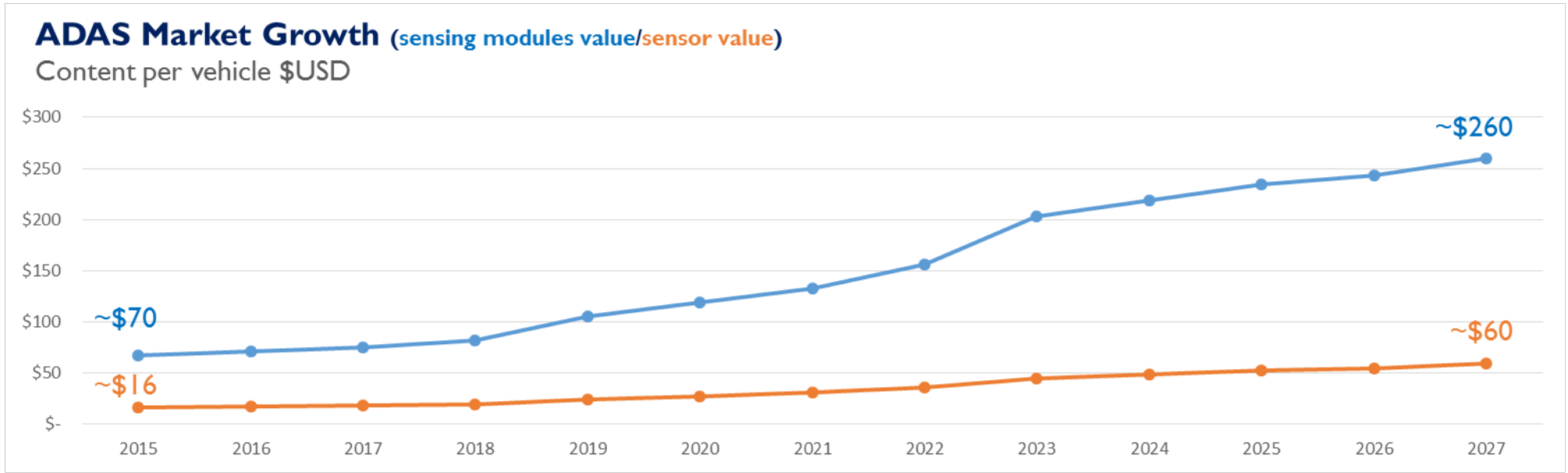
FROM ISP TO SENSOR FUSION PROCESSOR



ADAS GROWTH AND VALUE












ADAS will drive the market with security features

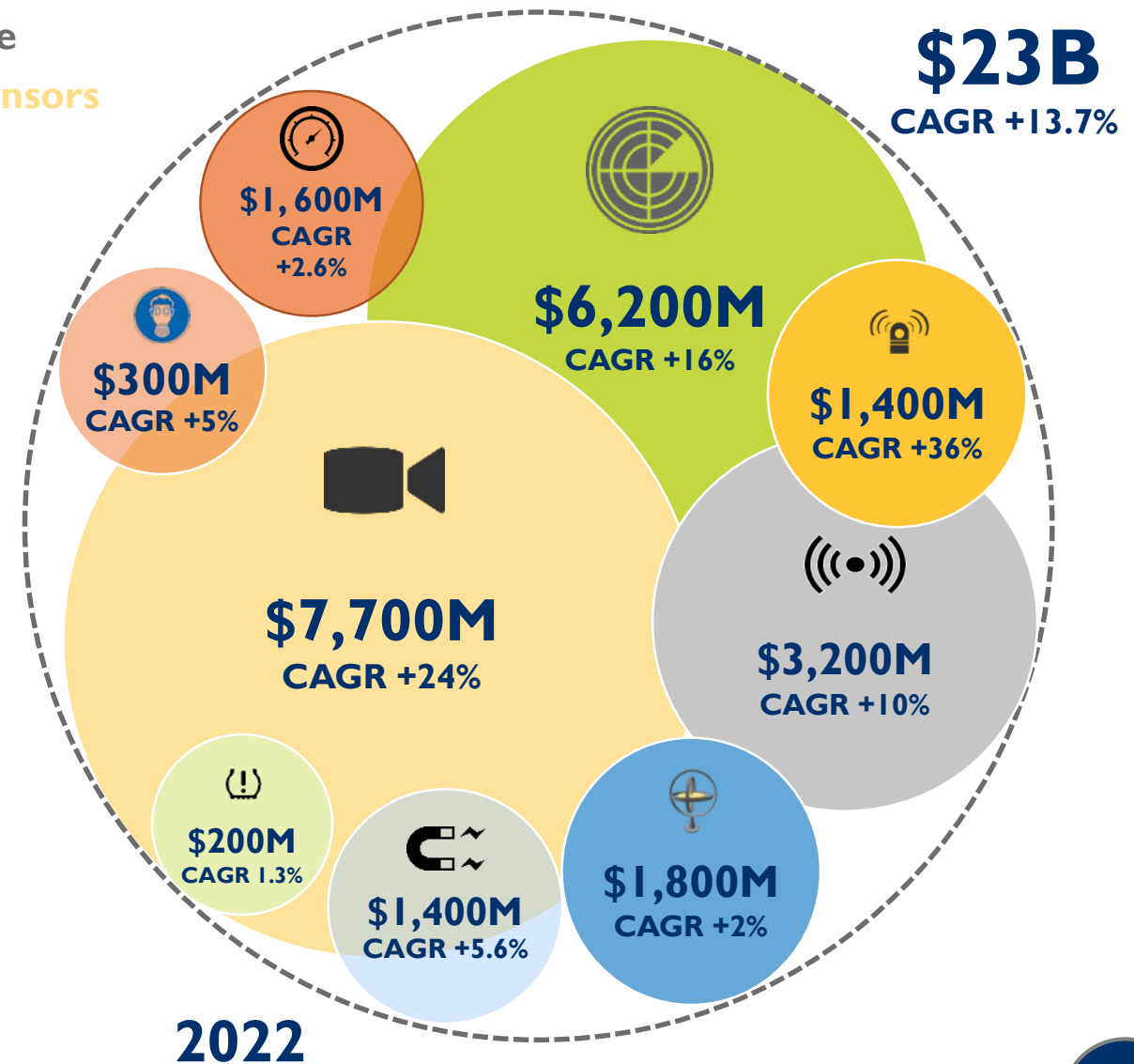
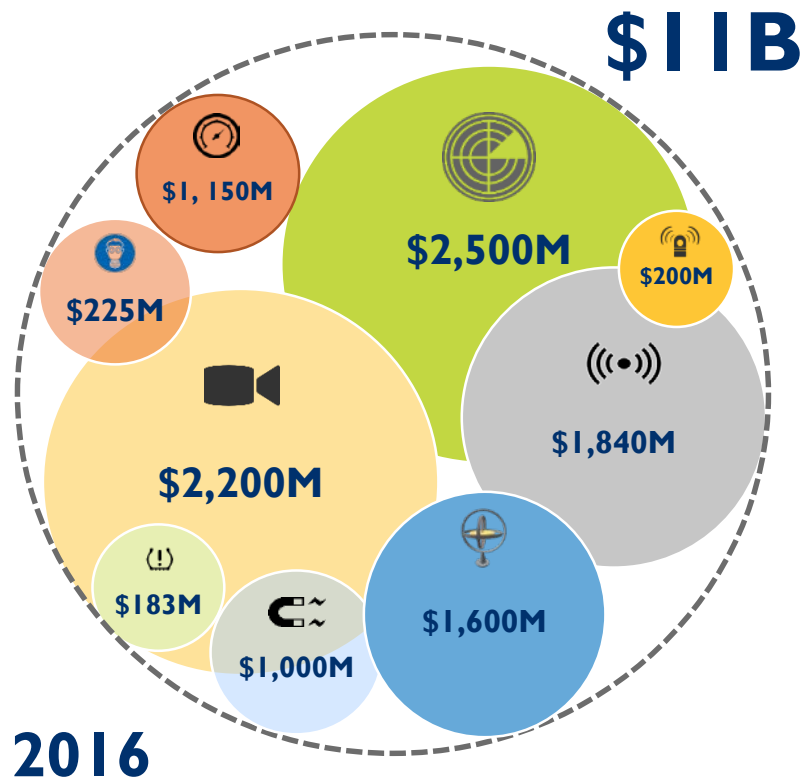


SENSORS FOR THE AUTOMOTIVE INDUSTRY - ECOSYSTEM

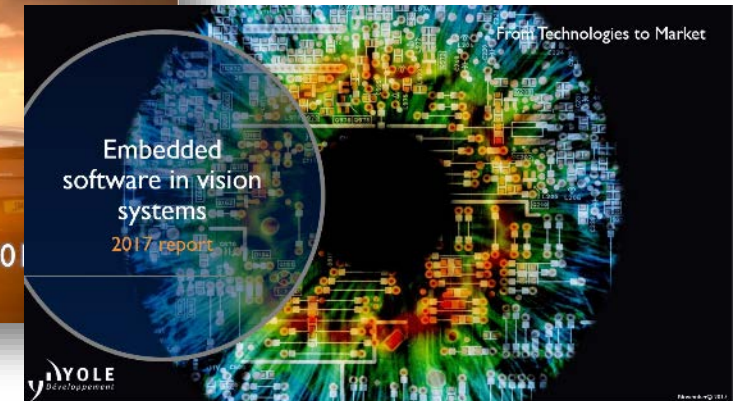
2016 - 2022 forecast

- Total sensor market value for automotive
-  **Radar sensors**
 -  **Imaging sensors**
 -  **LiDAR sensors**
 -  **TPMS**
 -  **Chemical sensors**
 -  **Inertial**
 -  **Magnetic**
 -  **Ultrasonic**
 -  **Pressure sensors**

The two main growth areas are imaging and radar/LiDAR sensors, driven by automation



Previous slides extracted from those reports



For more information:

www.i-Micronews.com

www.yole.fr

Next Up – Farid Hamrani



System Reverse Costing Analysis

Farid joined SystemPlus Consulting in 2016 as a system costing engineer. He is in charge of systems reverse cost analysis with a focus on embedded systems. He previously worked in the high-reliability packaging field. Farid holds a master degree in microelectronics and materials from the University of Nantes.

"SMART AUTOMOTIVE:" LATEST TRENDS IN LIDAR AND SENSORS

Smart Automotive and Sensor
Free Webcast, October 27th

Farid HAMRANI
System Cost Engineer



Reverse Costing® is the process of disassembling a device (or a system) in order to identify its technology and calculate its manufacturing cost, using in-house models and tools.





Custom Analyses
(>130 analyses per year)

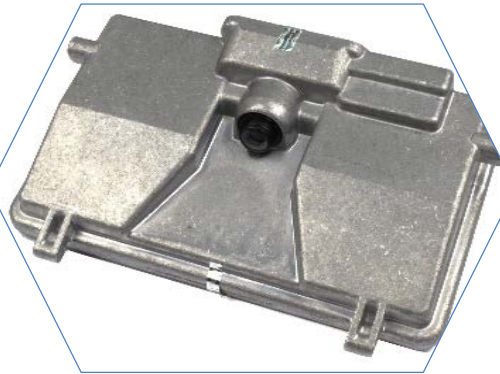
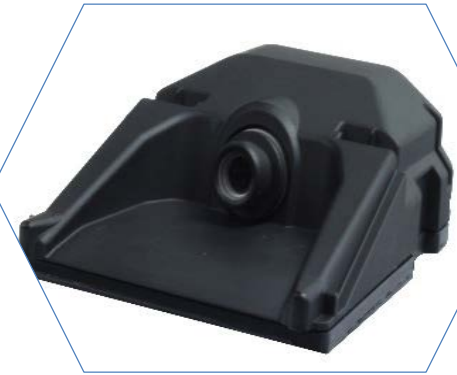
Reports
(>40 reports per year)

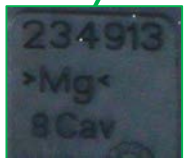
Costing Tools

Trainings

Forward Cameras

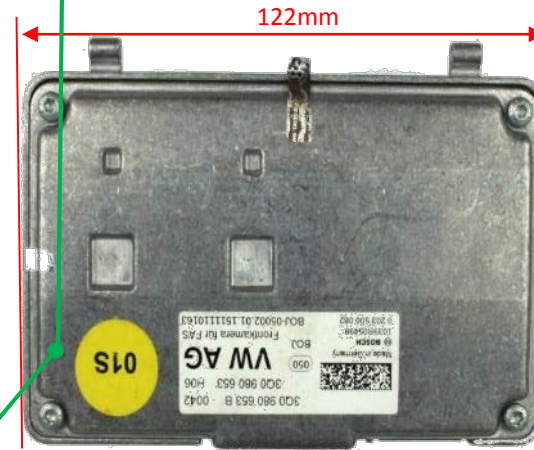
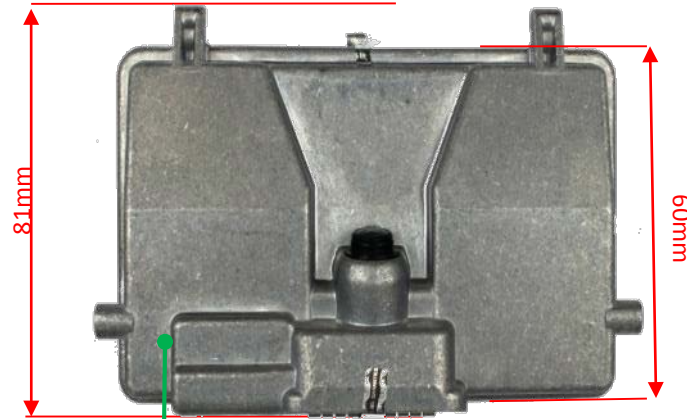
- A state of the Art Comparison





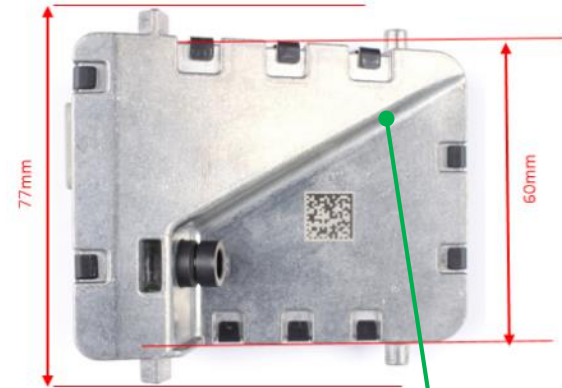
Total Mass: 70g

Anodized Magnesium



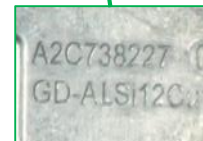
Total Mass: 205g

Aluminum Silicon Copper Alloy



Total Mass: 135g

Aluminum Magnesium Alloy



Aluminum Silicon Copper Alloy

TRW – SCam3

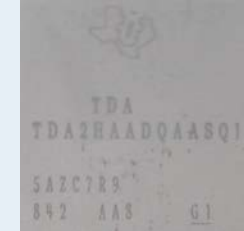
Bosch MPC2 Automotive Camera

Continental MFC 430TA

System on Chip (SOC)



Mobileye
STME EYEQ3*
SoC Processor For Vision Based
Driver Assistance Systems
FCBGA529



Texas Instruments
TDA2HAADQAASQ1
ADAS Applications
Processor
FCBGA625

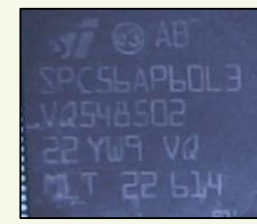
Microcontroller (MCU)



NXP Semiconductors
SPC5643LF2MLQ1
MCU 32-bit MPC56xx
e200 RISC 1024KB
Flash 3.3V/5V
257WBGA



Xilinx
XA7Z020-1CLG400Q
MCU Dual ARM® Cortex®-
A9 MPCore 32-Bit
BGA400 (x2)



ST Microelectronics
SPC56AP60L3
32-bit Power
Architecture® based
MCU
LQFP100

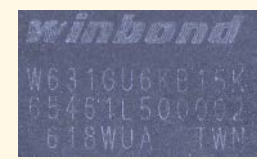
Random Access Memory (RAM)



Micron Technology
**MT42L32M32D2AC-
25FAAT:A TR**
IC Memory 1GBit
(32Mx 32) DDR2
VFBGA134



Micron Technology
**MT42L128M32D1TK-
25 AAT:A**
DRAM LPDDR2 SDRAM
4G-Bit FBGA134
(+1Gbit from Micron)



Winbond
W631GU6KB15K
8M x 8Banks x 16 bit
DDR3L SDRAM
WBGA96

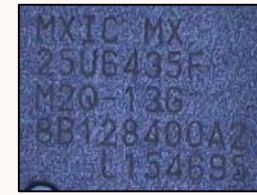
Flash Memory



Spansion
S25FL256SDSBHVCO
Flash Non-Volatile
Memory 256MBit
80MHz 3.0V
BGA24 (+128MBit)



**Spansion
Semiconductor**
S25FL128SAGBHIA00
SRAM 128Mb
133MHz 3V FBGA24
(x2)



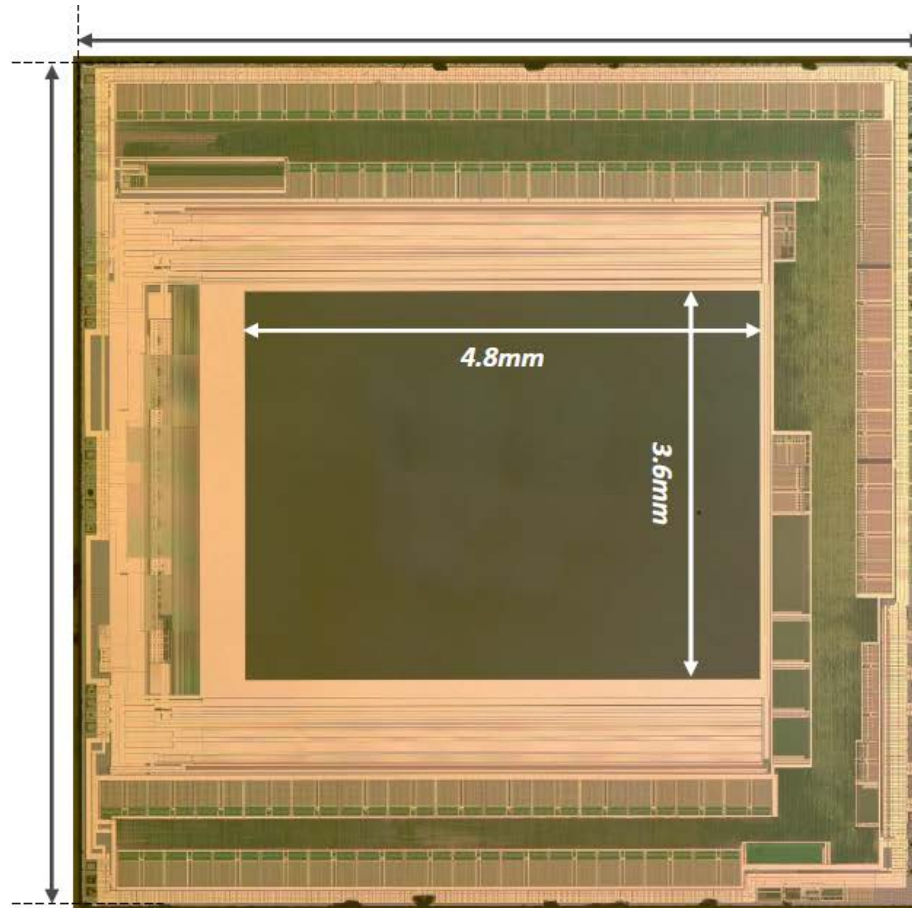
Macromix
MX25U6435F
1.8V 64M-BIT CMOS
MXSMIO FLASH
MEMORY
SOP8

CMOS Image Sensor

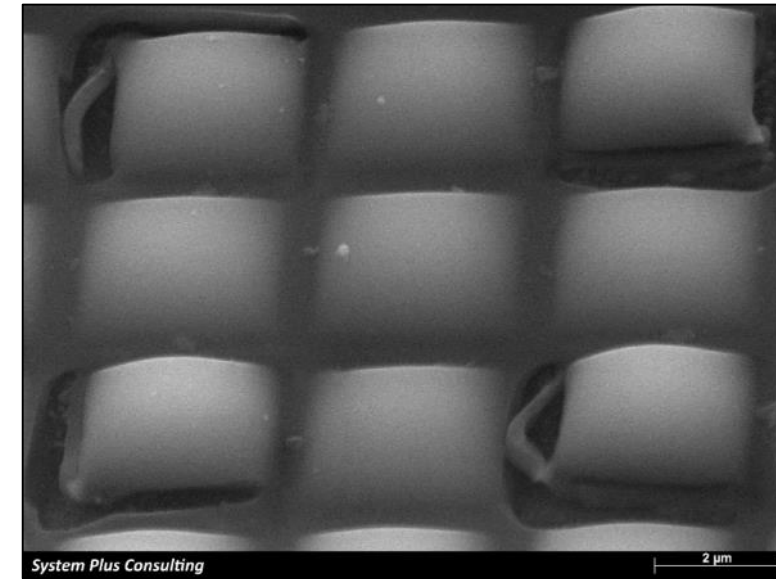
- ON Semiconductor AR0132AT (formely Aptina)



ON Semiconductor



CIS top view.



Pixel array: **17.3mm²**
(4.8mm x 3.6mm)

CIS resolution: 1280 x 960 (1.2Mp)

→ Pixel area: **14.06µm²**

→ Pixel size: **3.75µm x 3.75µm**

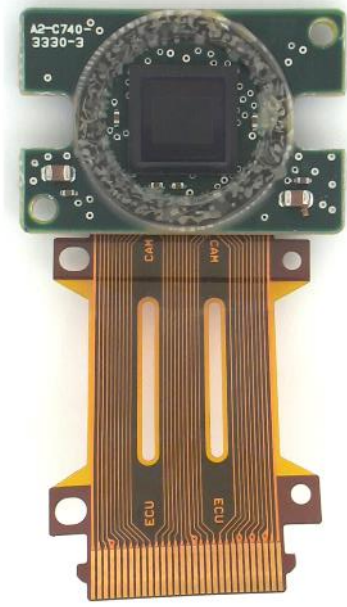
TRW – SCam3



Bosch MPC2 Automotive Camera

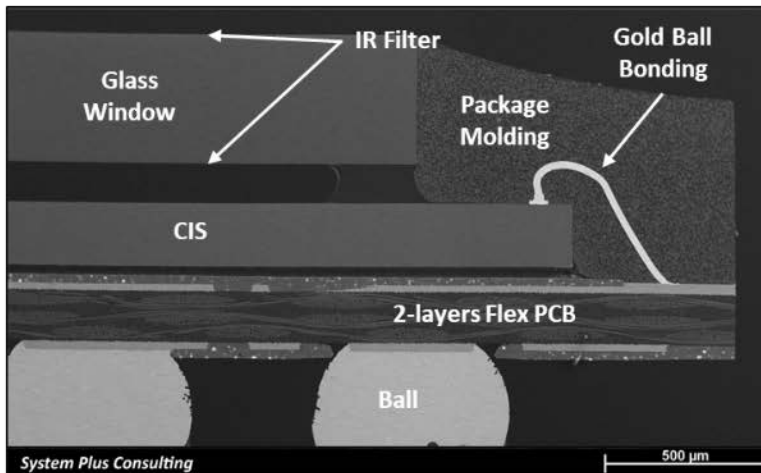


Continental MFC 430TA

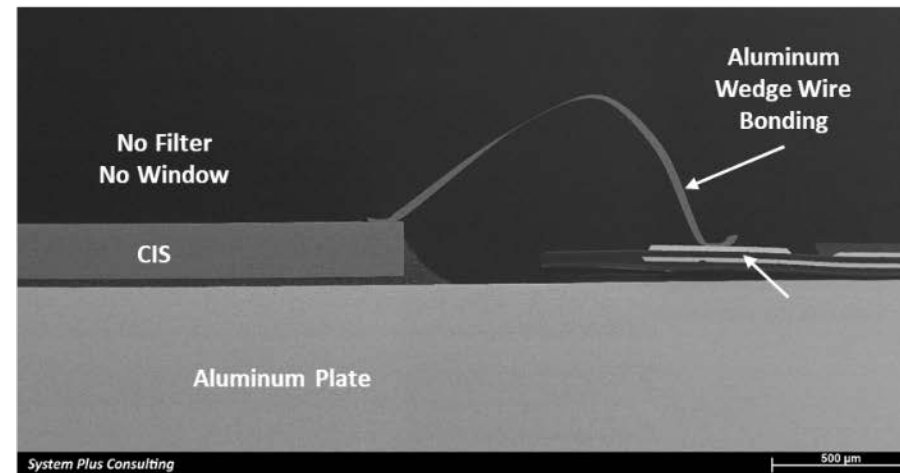


TRW – SCam3

Continental MFC 430TA



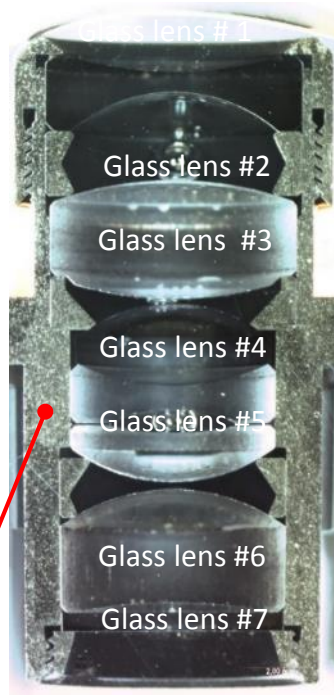
Bosch MPC2 Automotive Camera



Package Cross-Section – SEM View

Die Cross-Section – SEM View

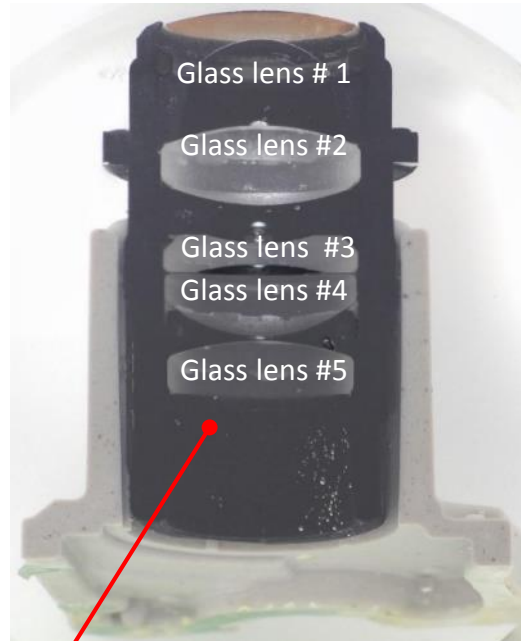
TRW – SCam3



Brass



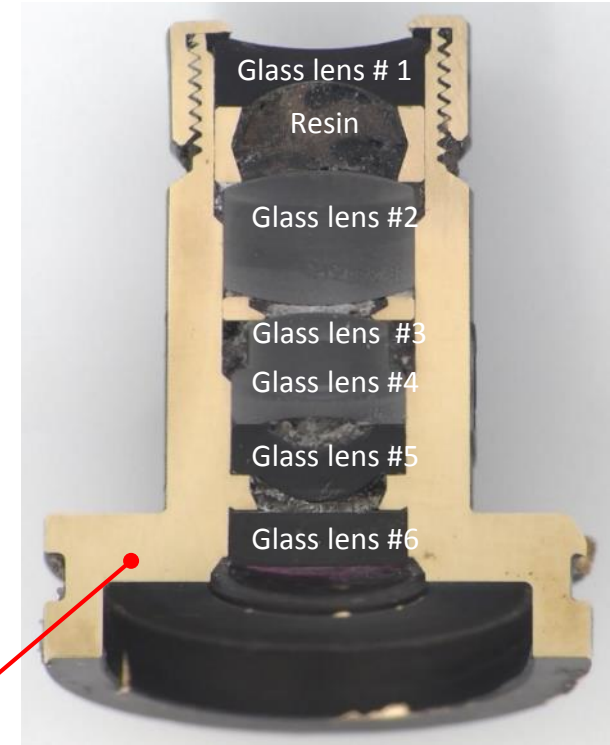
Bosch MPC2 Automotive Camera



Plastic Housing Holder Lens



Continental MFC 430TA

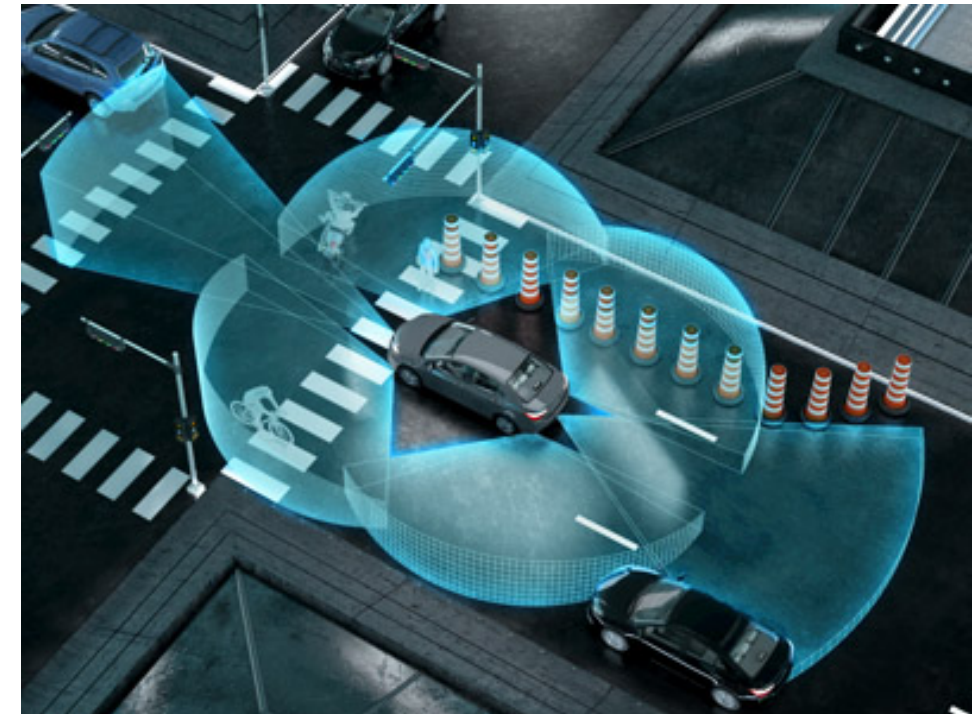


Brass



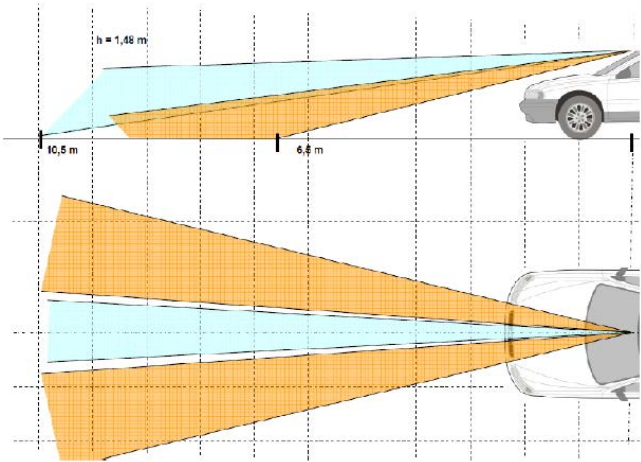
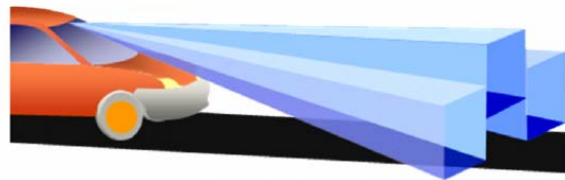
LiDARs

- Two Type of solid state LIDARS

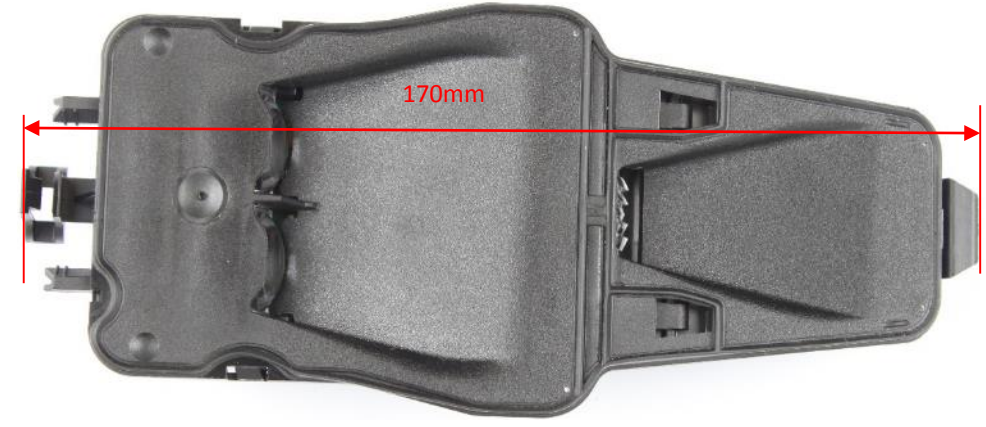
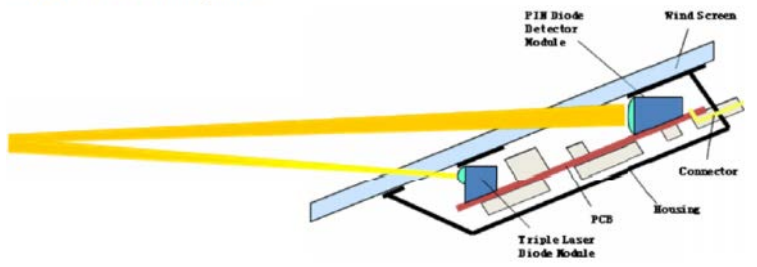


Continental Short Range Lidar SRL-1

- Views & Dimensions

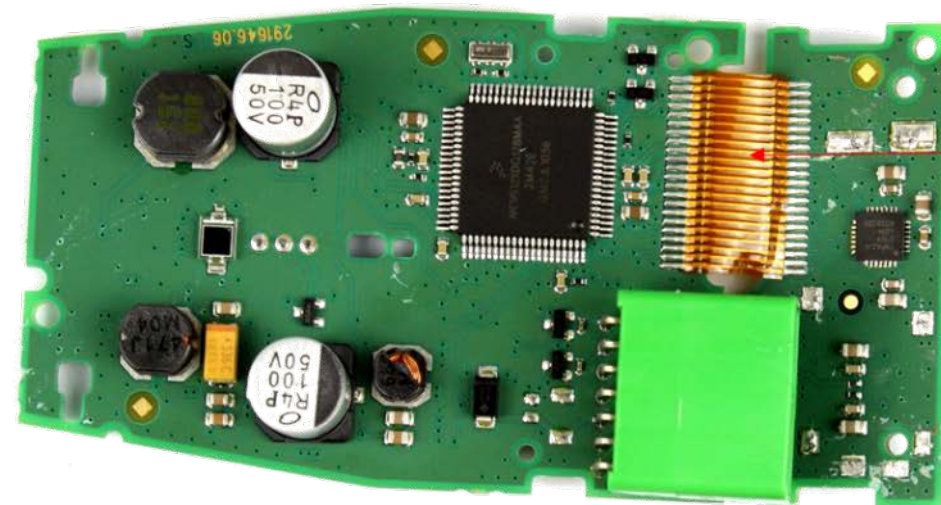
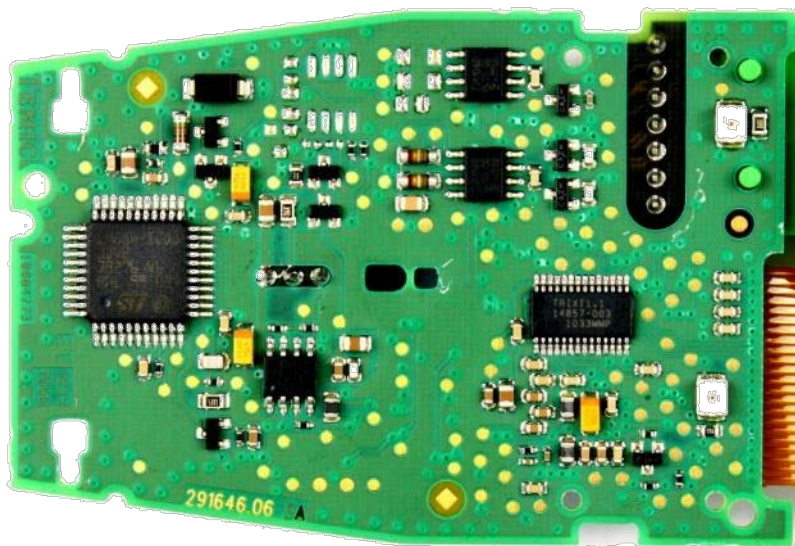


SRL 1 Short Description

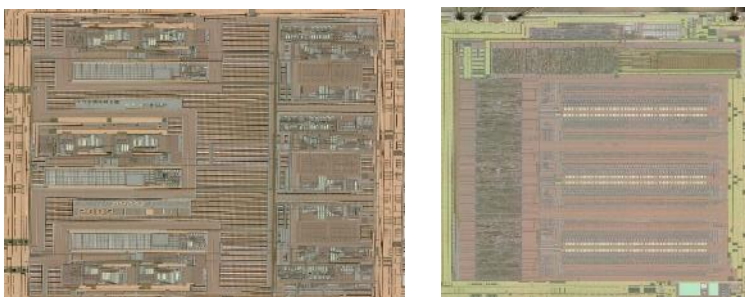


Continental SRL-1

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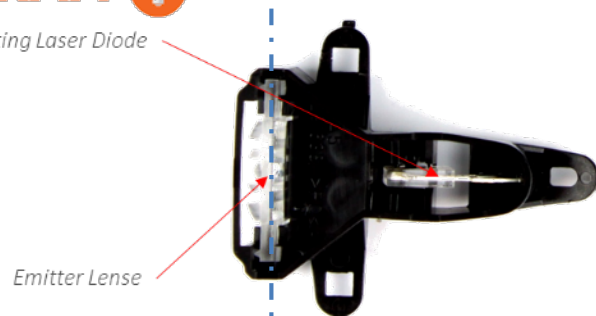
Flex Cable



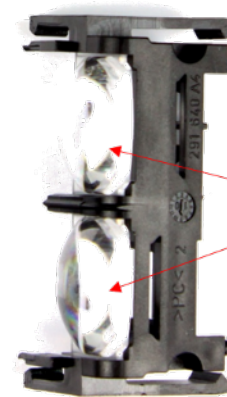
ASIC / ASSP by AMS
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Emitting Laser Diode



Emitter Lens



Receiver Lenses

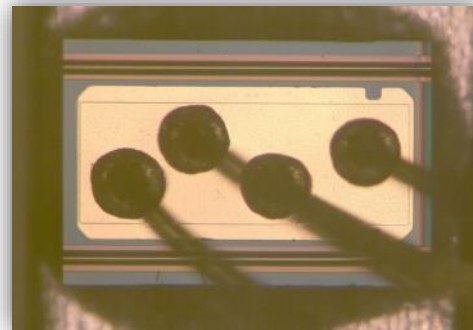
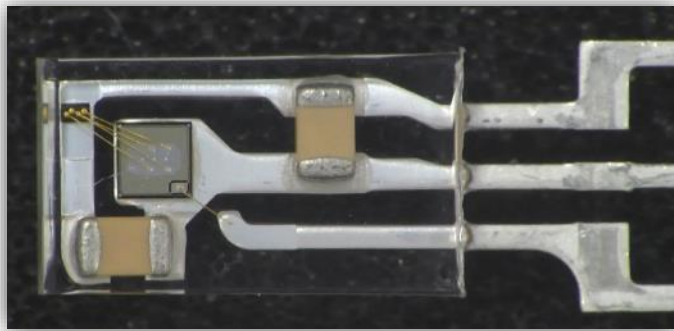


Board Disassembly

Not to scale

□ Continental SRL-1 – Emitting Diode

- The Osram SPL LL90-3 is an Hybrid Pulsed Laser Diode for LIDAR.
- The die is manufactured on strained InAlGaAs/GaAs QW-structures technology.



OSRAM SPL LL90-3
©2017 by System Plus Consulting

LeddarTech LeddarVu8 LiDAR



LeddarTech® LeddarVu

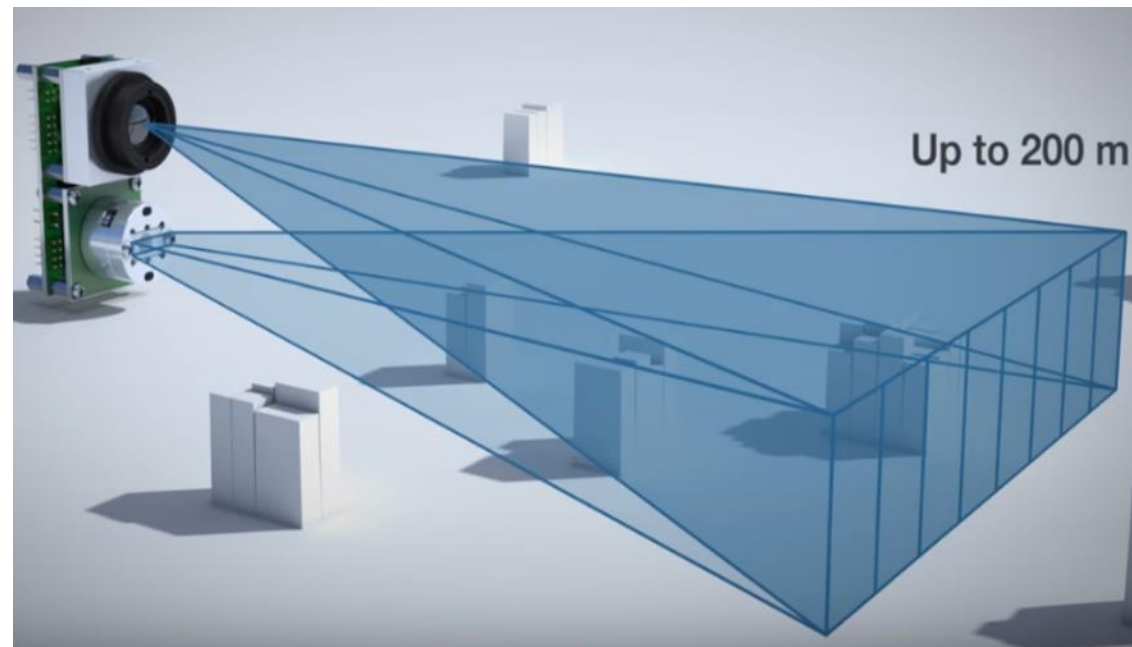
System performance

- Accuracy** 5 cm
- Data refresh rate** up to 100 Hz¹
- Operating temperature range** -40°C to +85°C
- Distance precision** 6 mm
- Distance resolution** 10 mm
- Power consumption** 2 W



Configurations	Vu8 - 020		Vu8 - 048		Vu8 - 100		
Horizontal FoV	20°		48°		100°		
Vertical FoV	0.3°	3°	0.3°	3°	0.3°	3°	
Dimensions	70 mm x 35.2 mm x 67.5 mm		70 mm x 35.2 mm x 45.8 mm		73 mm x 40 mm x 65 mm		
Weight	80 g		75 g		97 g		
Range	Retro-Reflector ¹	215 m	121 m	118 m	85 m	61 m	34 m
	White Target ²	60 m	34 m	31 m	19 m	12 m	9 m
	Grey Target ³	38 m	22 m	18 m	13 m	7 m	6 m

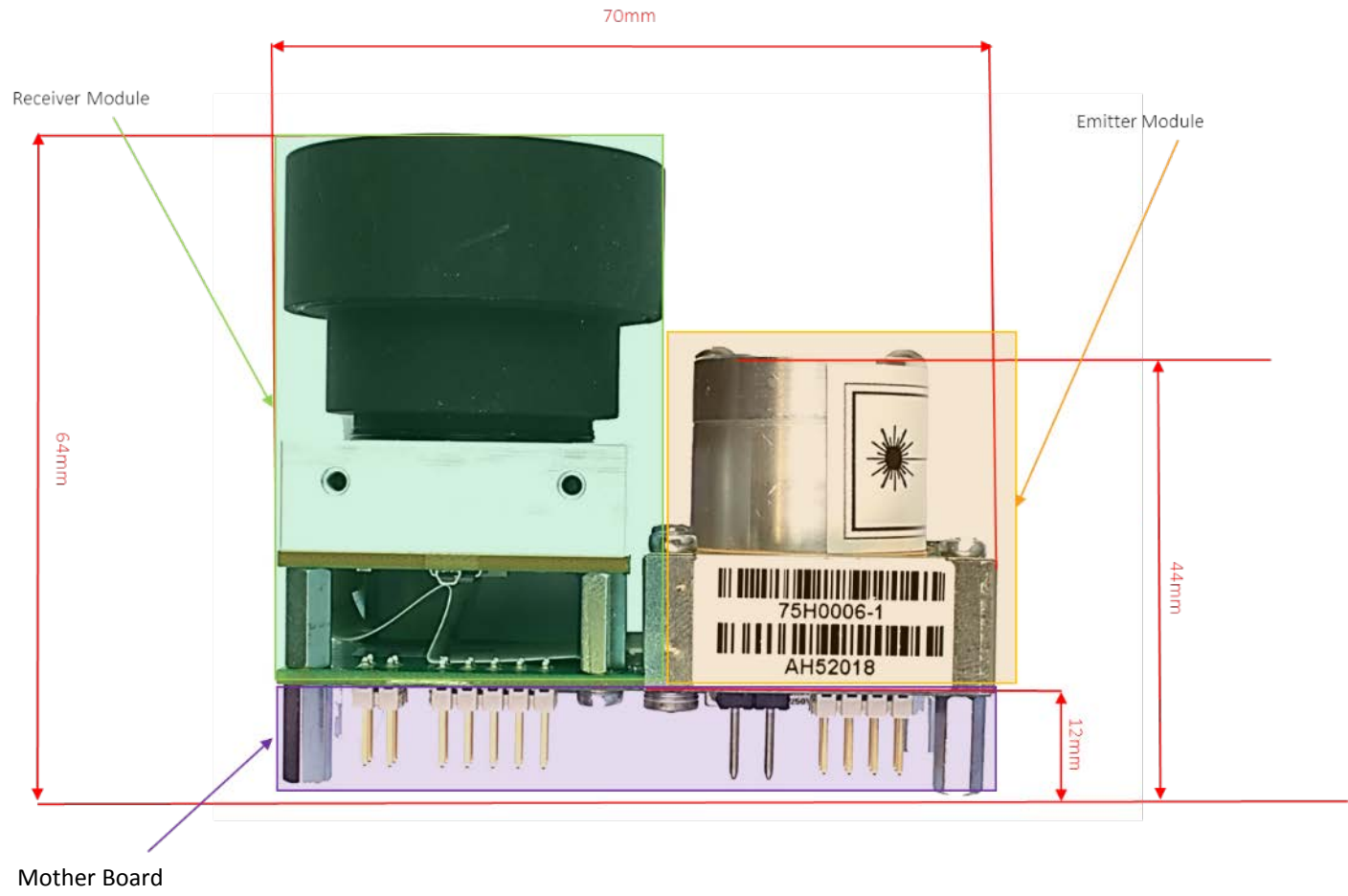
Performance Review
©2017 by LeddarTech



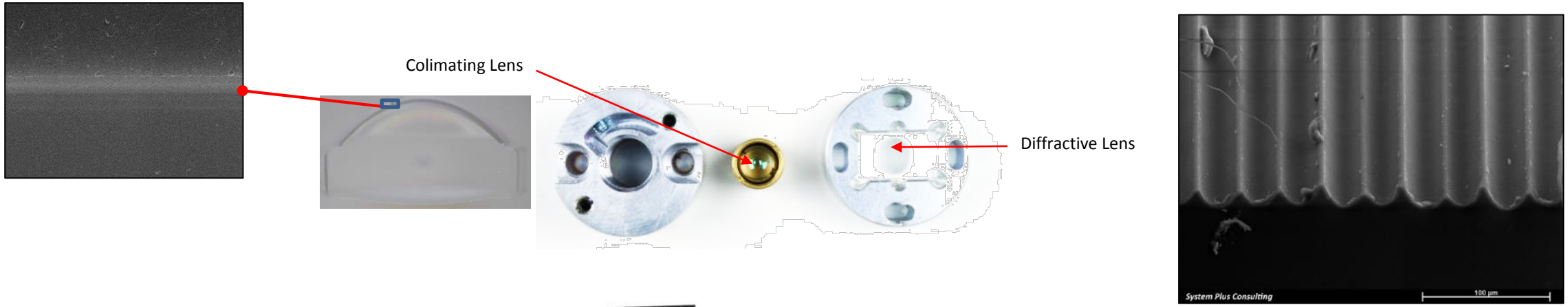
Demonstration
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Global View
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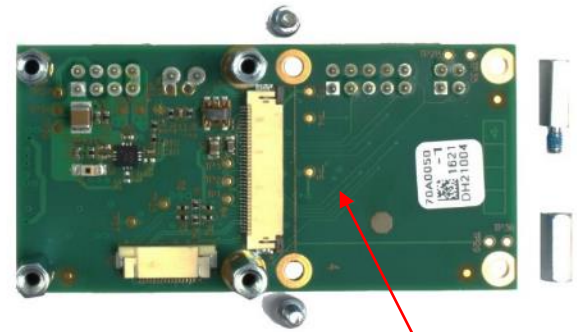
Side View and Dimension
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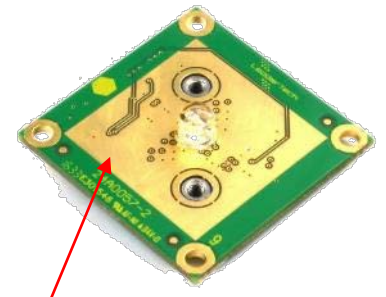
Receiver Module Lens



Photodiode Array



Mother Board



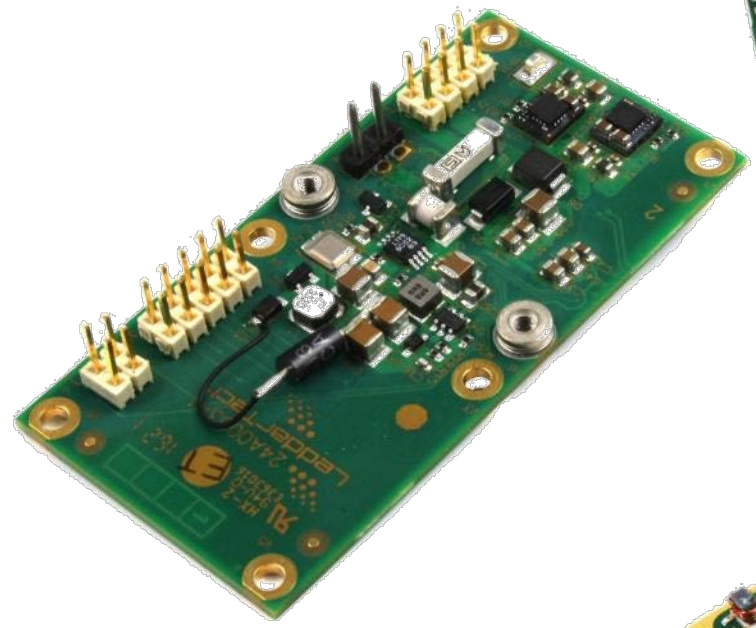
Emitter Board

Module Disassembly
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Block Diagram Description
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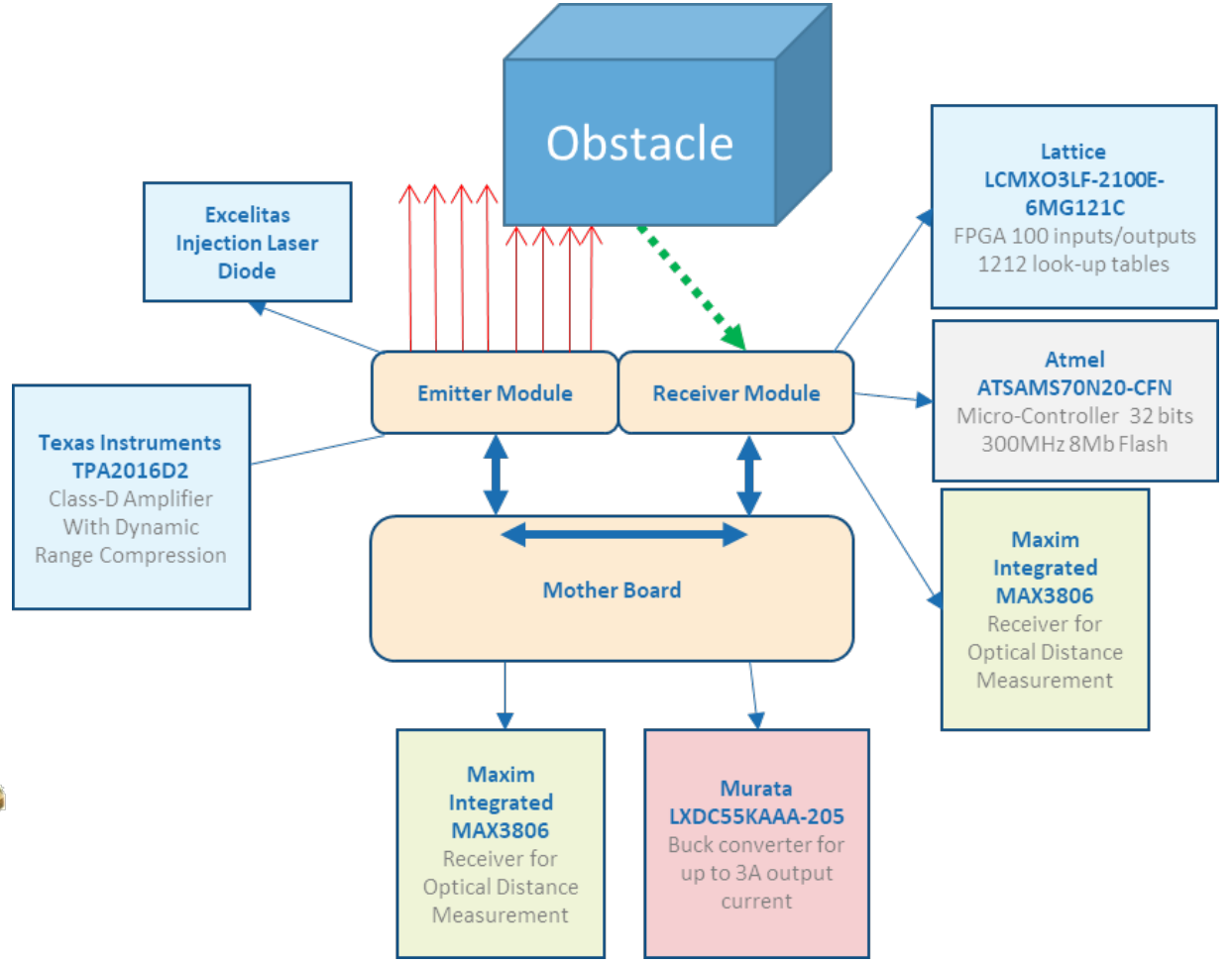
Emitter Board
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Mother Board
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Receiver Board
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□ Leddartech LeddarVu8 – Emitting Diode

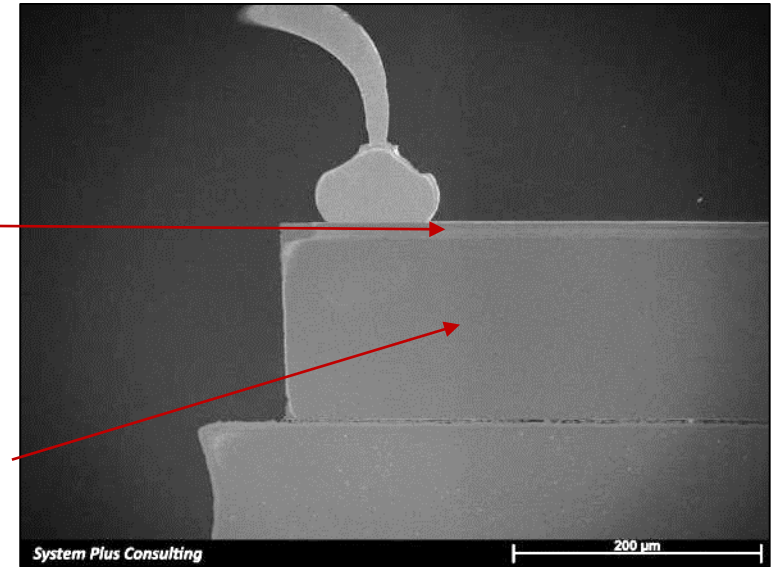
- The Excelitas TPGEW1S09H is an Hybrid Pulsed Laser Diode for LIDAR.
- The TPGEW1S09H is an Edge Emitting Laser infra red 905nm pulsed laser diode.



Top Optical View
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The active layers: epitaxied
InAlGaAs layers

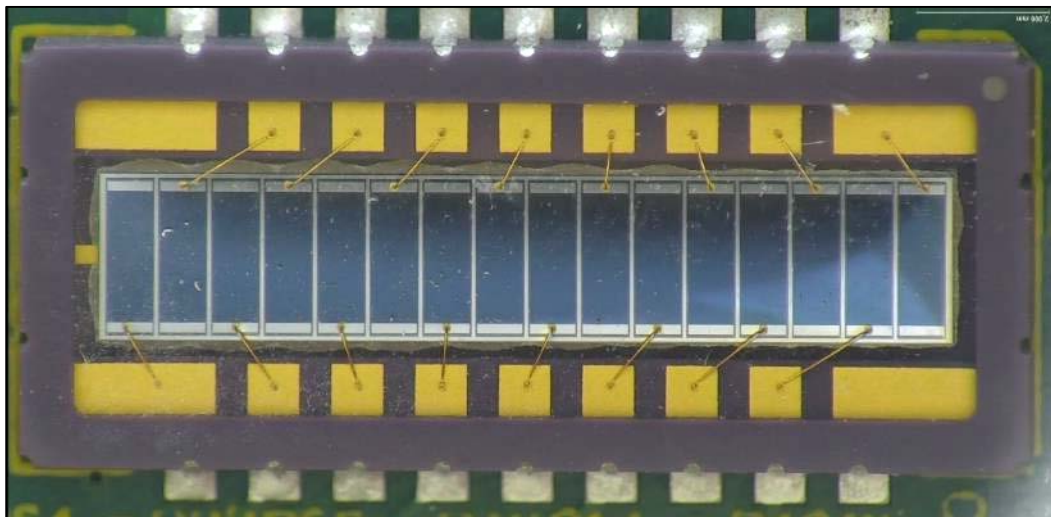
GaAs substrate probably heavily
doped to conduct the current.



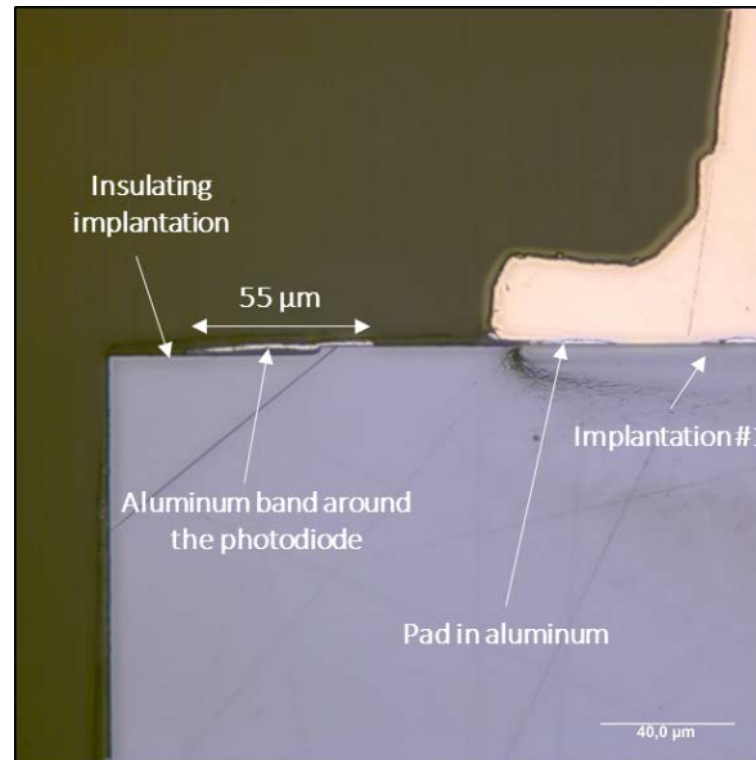
SEM Cross-Section
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☐ Leddartech LeddarVu8 – Receiving Photodiode

- 16 elements PIN Silicon photodiode linear array from Hamamatsu.



Top Optical View
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SEM Cross-Section
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Q&A