

EPIC technology conference

Key photonic market trends

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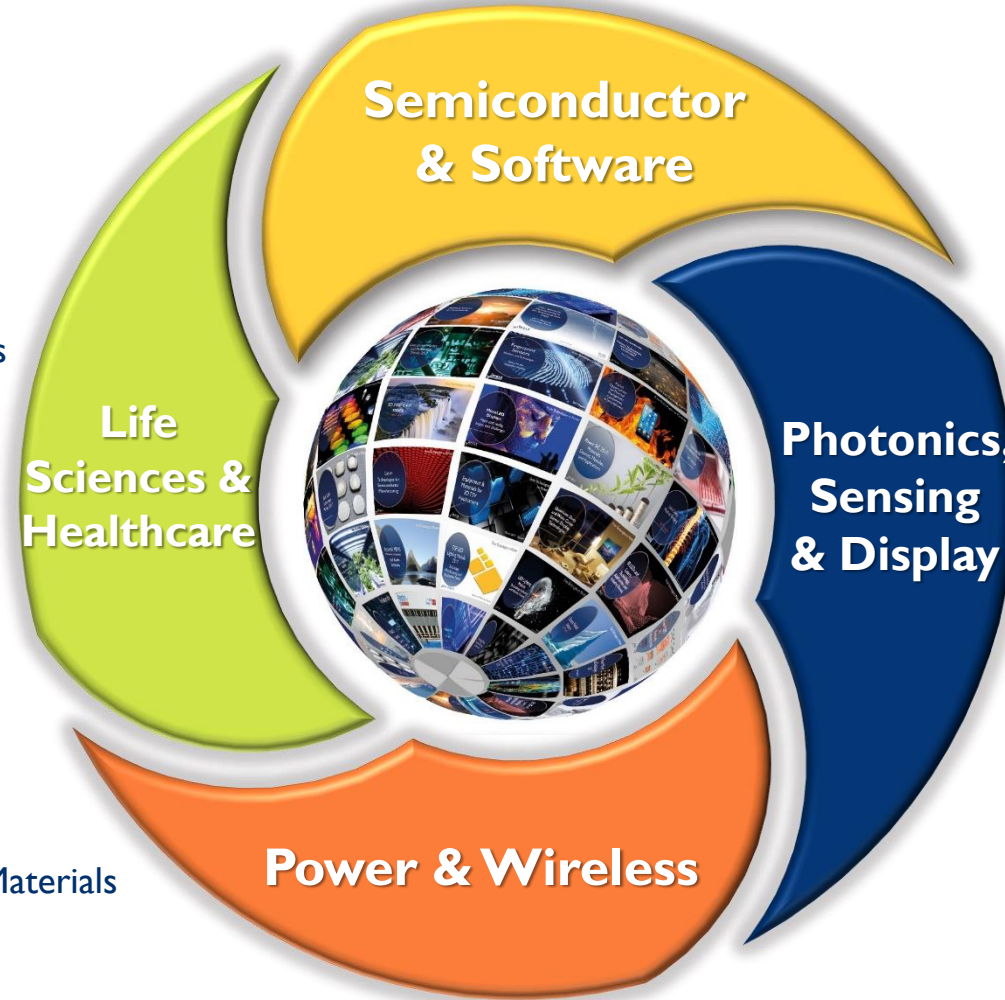


Life Sciences & Healthcare

- 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)

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

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- Excel database covering supply, demand, and technology
- Price, market, demand and production forecasts
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SOLID STATE LIGHTING SOURCE - MARKET FORECAST

Scope of applications

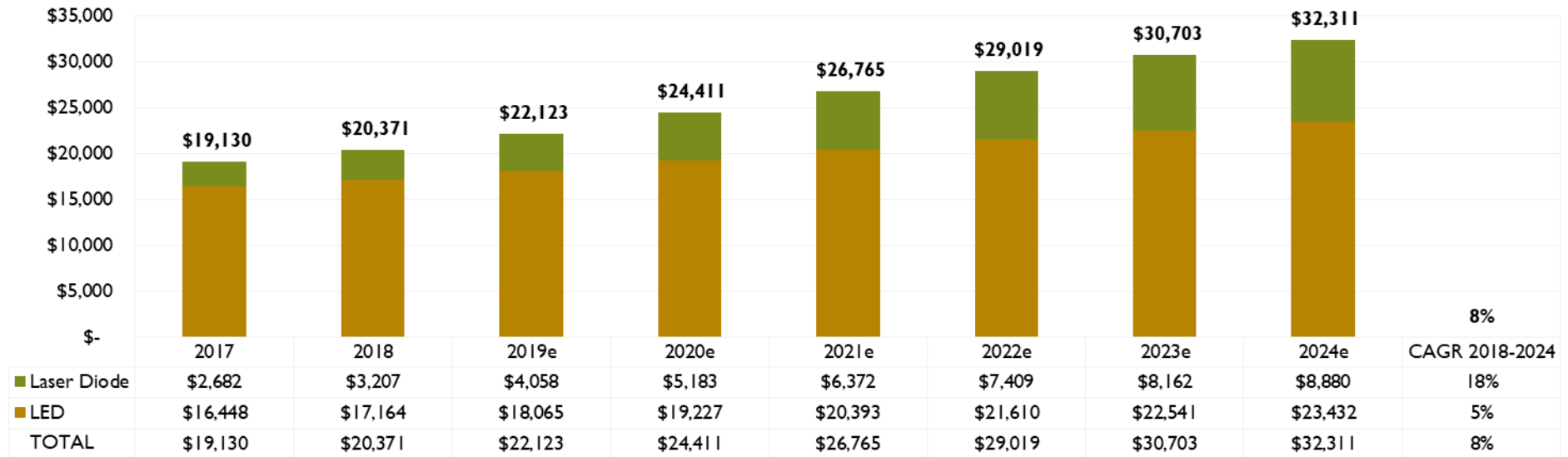
	Mobile & Consumer	Automotive & Transportation	Telecom & Infrastructure	Medical	Industrial	Defense & Aerospace
Visible LED	<ul style="list-style-type: none"> LCD TVs and monitors Notebooks and tablets Mobiles - display & flash General lighting systems 	<ul style="list-style-type: none"> Automotive lighting systems 			<ul style="list-style-type: none"> Direct view displays General lighting systems Horticultural lighting systems 	<p>Some few applications exist for defense & aerospace segment but are not included in our analysis as representing less than 0.1% of SSL source market revenues</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 rangefinders - 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 applications in black are involved in multiple SSL sources.

SOLID STATE LIGHTING SOURCE - MARKET FORECAST

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

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



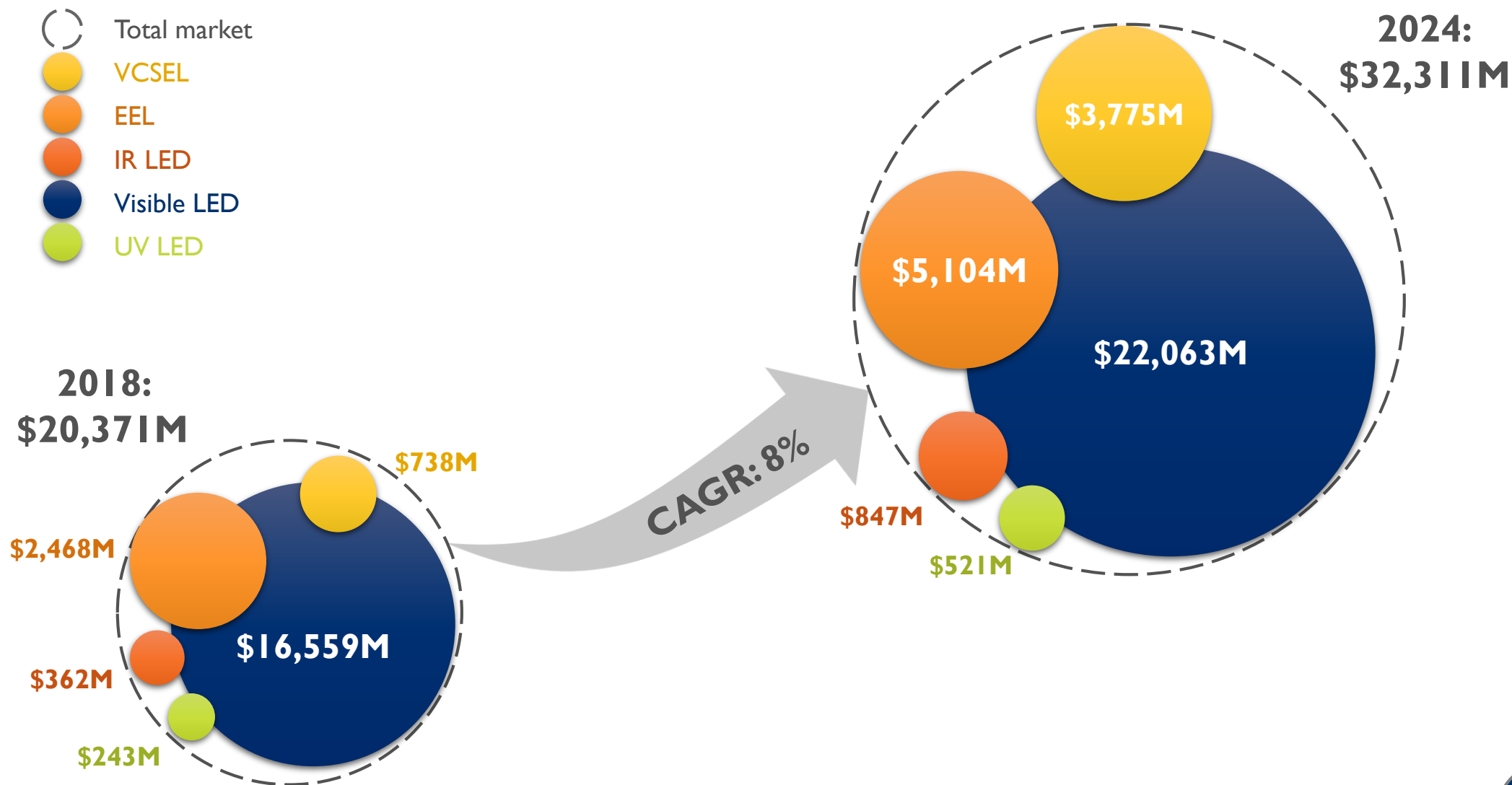
SSL source market will grow from ~\$20.4B in 2018 to ~\$32.3B in 2024 at a CAGR of 8%.

- SSL source market is mostly driven by LED devices which represented ~84% of total revenue in 2018. However this share is likely to decrease to ~73% in 2024.
- Indeed, LED market is starting to reach a plateau ($CAGR_{2018-2024} = 5\%$) whereas laser diode market is growing rapidly ($CAGR_{2018-2024} = 18\%$).
- We expect this trend to continue after 2024 as:
 - LED technology will reach saturation in most of the key applications targeted (eg displays, general lighting) and there is little potential for new applications to emerge in a way that could compensate for the size of traditional applications.
 - Laser diodes still have a large potential for growth in traditional applications (eg optical transceivers) and several new applications are being investigated (eg LiDAR).

SOLID STATE LIGHTING SOURCE - MARKET FORECAST

2018 vs. 2024 Market forecast - Split by source type

An 8% CAGR is expected in the next 6 years with visible LED sources driving the market. In this time frame, VCSEL is the fastest growing with a CAGR of 31%.



CIS REVENUE FORECAST 2011 - 2023

By market (in \$M)

Revenue is dominated by mobile, consumer, and computing, which represent 85% of total 2016 CIS revenue. Mobile alone represents 67%.

Automotive will become the second-largest segment by 2018

From 2016 - 2022, global revenue growth will increase to a ~9.4% CAGR

2011-2023 CIS revenue forecast (in \$M)
by market

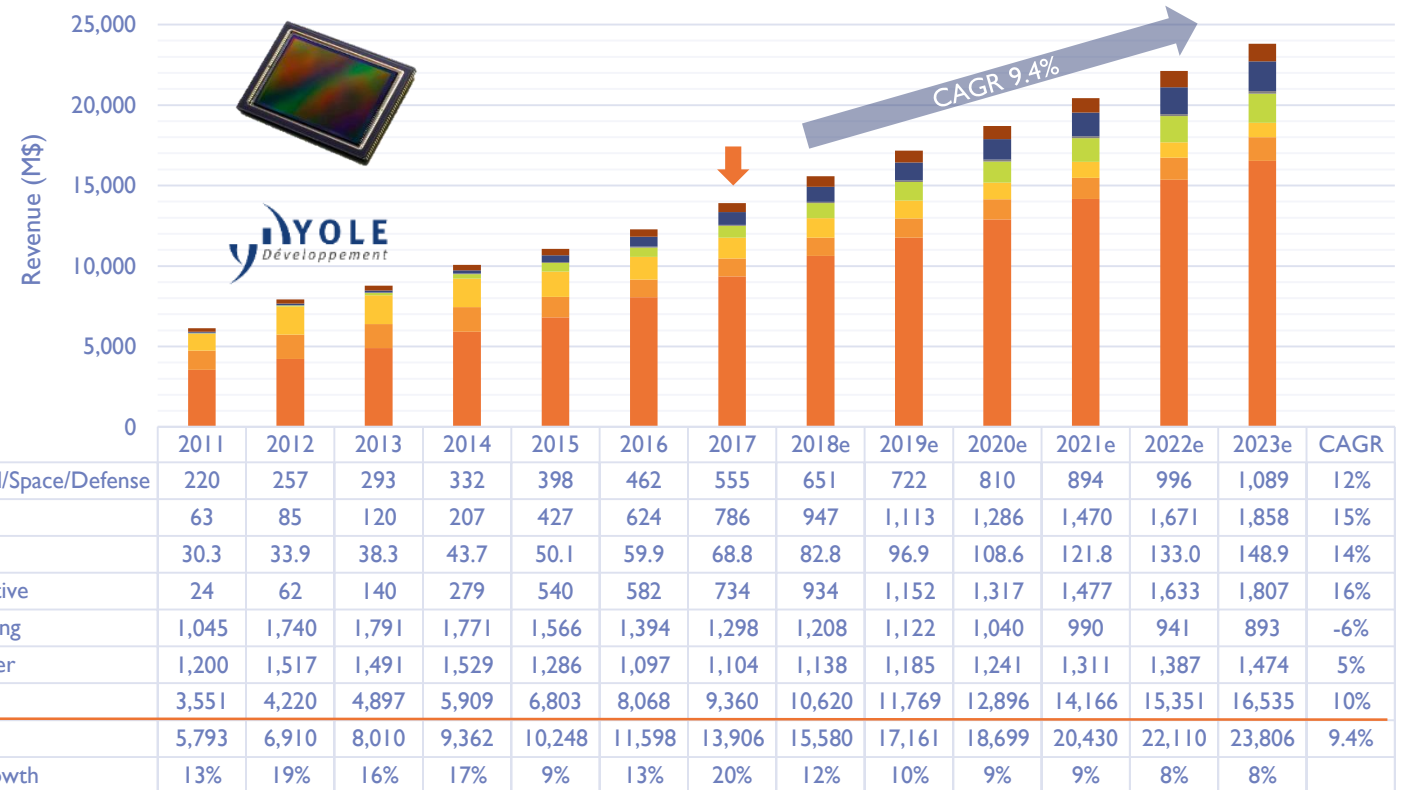
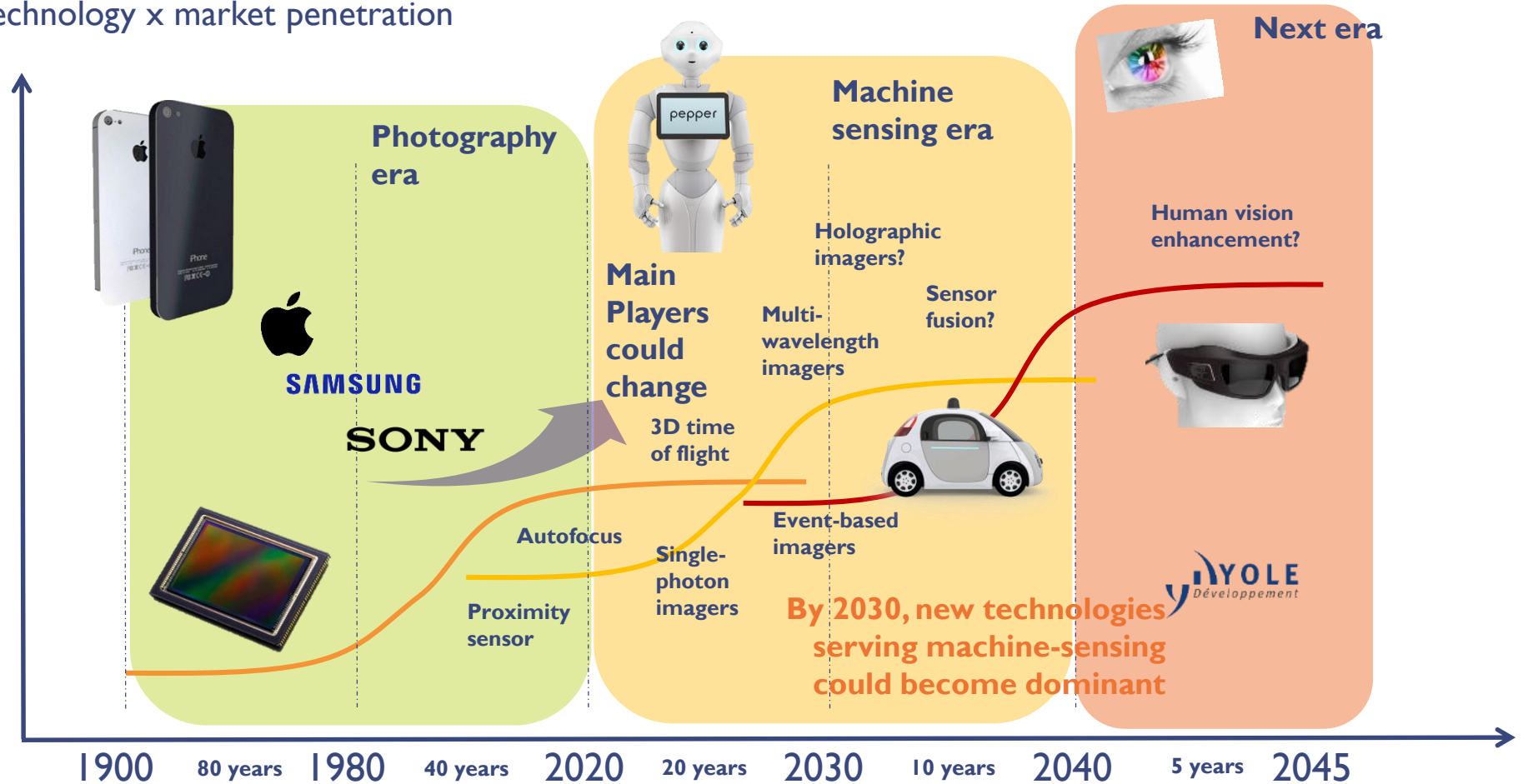


IMAGE SENSOR APPLICATIONS - WHAT'S NEXT?

A roadmap for the next **20** years

From
“vision for
imaging” to
“vision for
sensing”

Technology x market penetration



Acceleration - the speed of technology change doubles with every technological shift

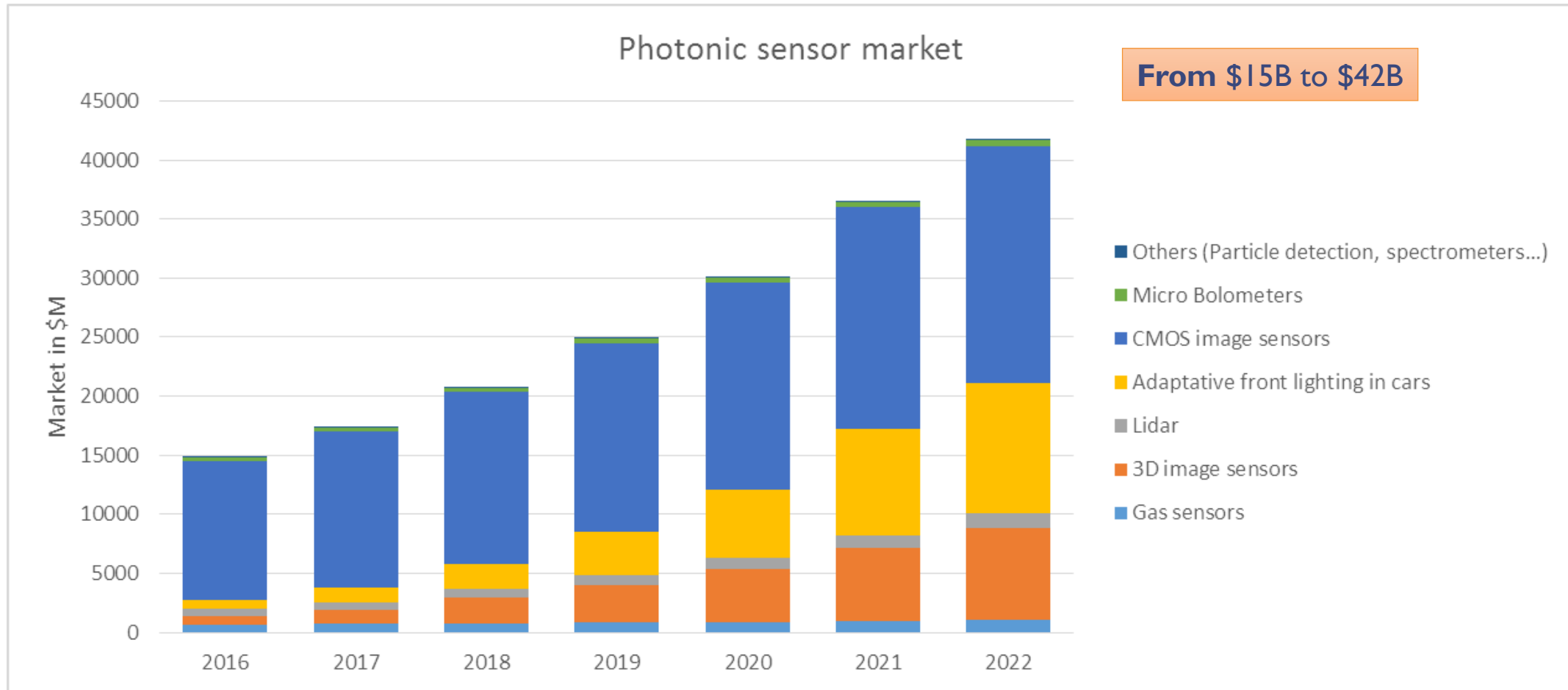


- The integration of multiple photonic devices (illumination device, light detector, lenses and processing) in a package/module/shoe box has the ability to impact a lot of different applications:
 - Gas sensors
 - 3D image sensors
 - Lidar
 - Adaptative front lighting in cars
 - Particle detection
 - Compact microspectrophotometre
 - Silicon photonics module for data center and high performance computing
 - ...

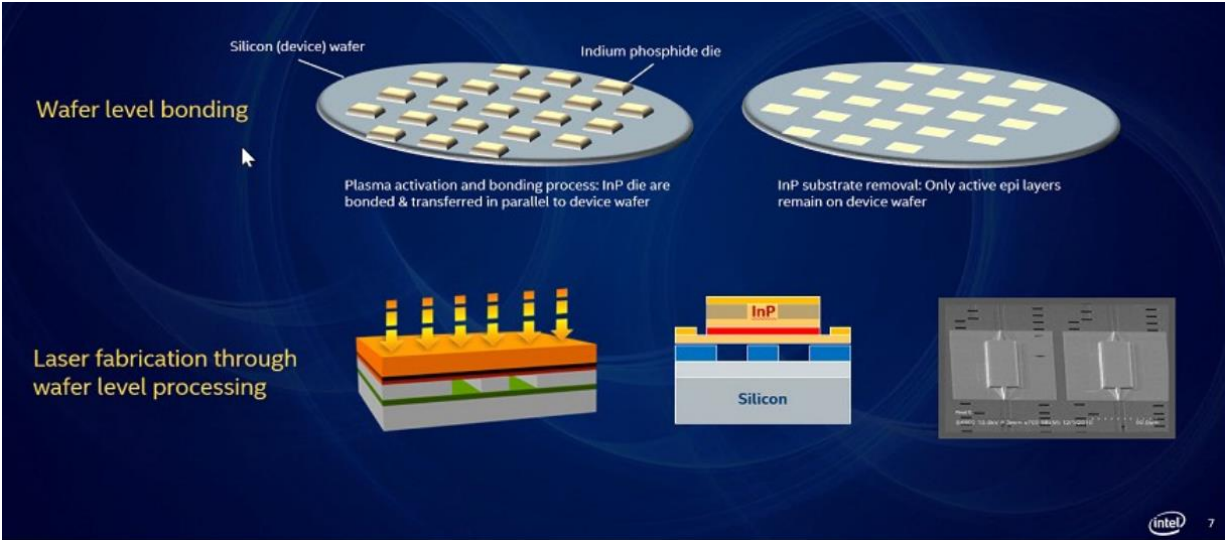
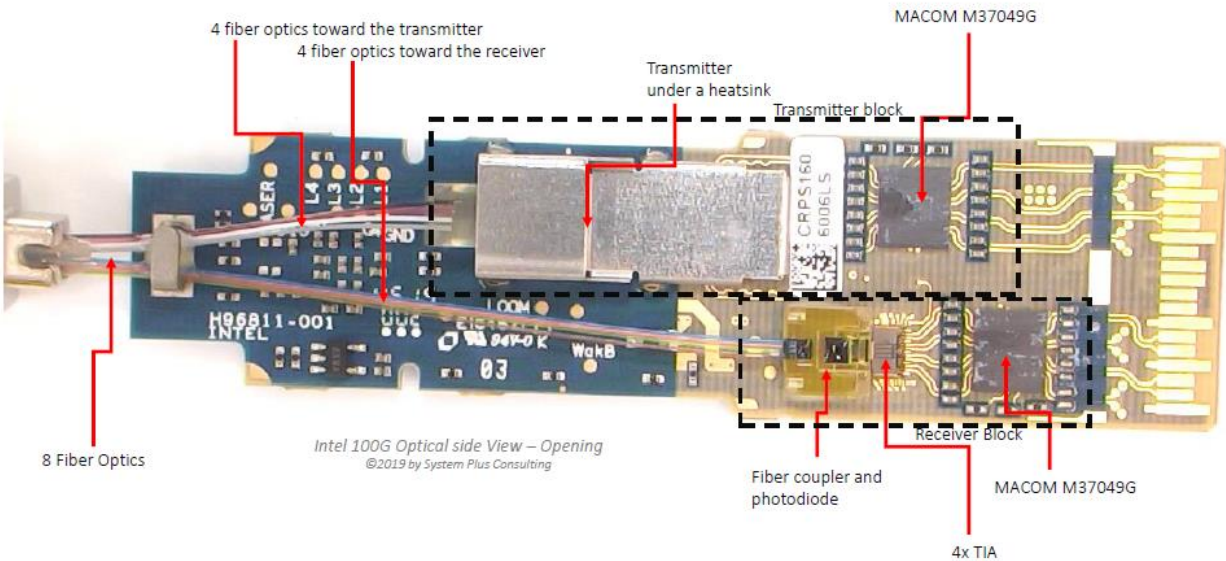
2016-2022 PHOTONIC SENSOR MARKET



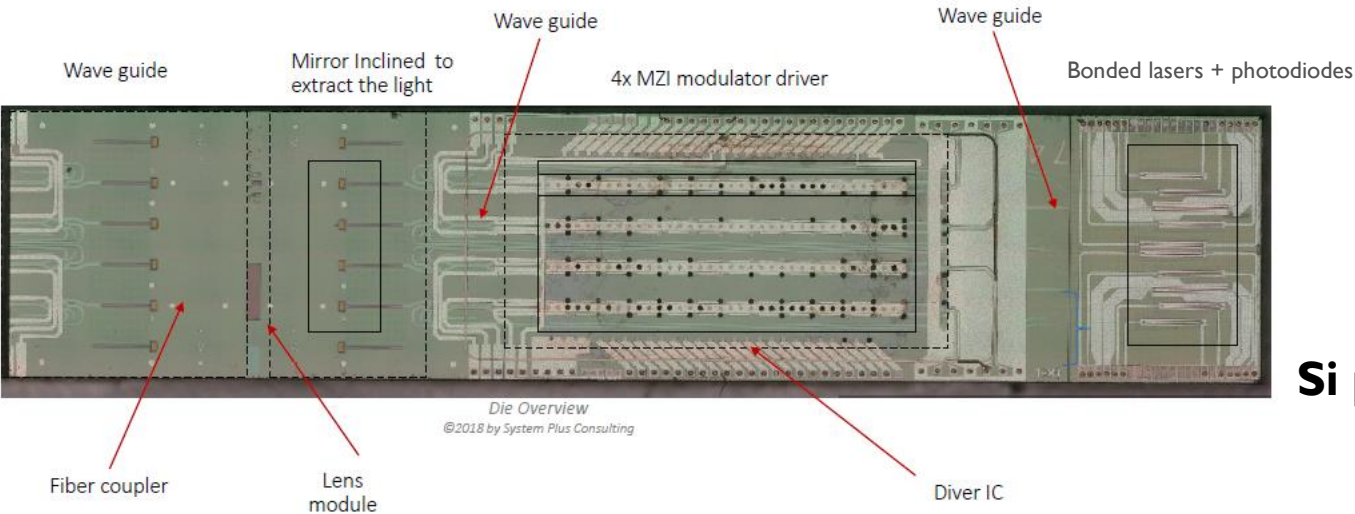
High growth
of 3D image
sensors and
adaptative
lightning



INTEL 100G PSM4 SI PHOTONICS TRANSCEIVER (SOURCE S+C)



Hybrid laser fabrication



Si photonics die

Dot Projector Teardown

[Overview / Introduction](#)

[Company Profile & Supply Chain](#)

[Physical Analysis](#)

- Synthesis
- Teardown
- Ceramic Package
- IC Broadcom
- NIR VCSEL
- ▶ **Folded Optic**
- Active DOE
- Comparison

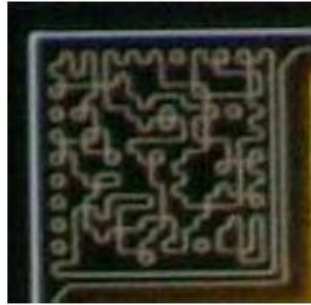
[Manufacturing Process Flow](#)

[Cost Analysis](#)

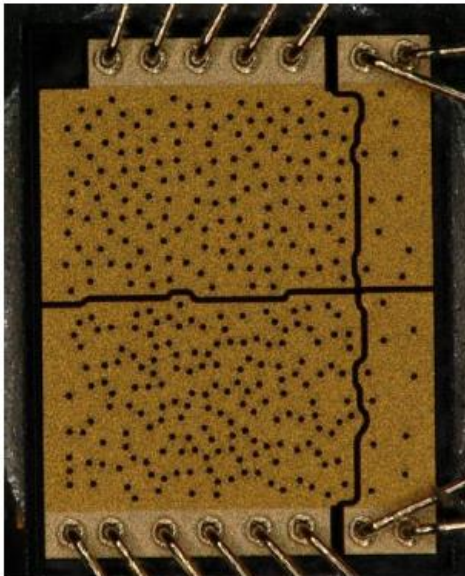
[Selling Price Analysis](#)

[About System Plus](#)

The optical block is glued on top of the ceramic substrate.



VCSEL Marking



VCSEL

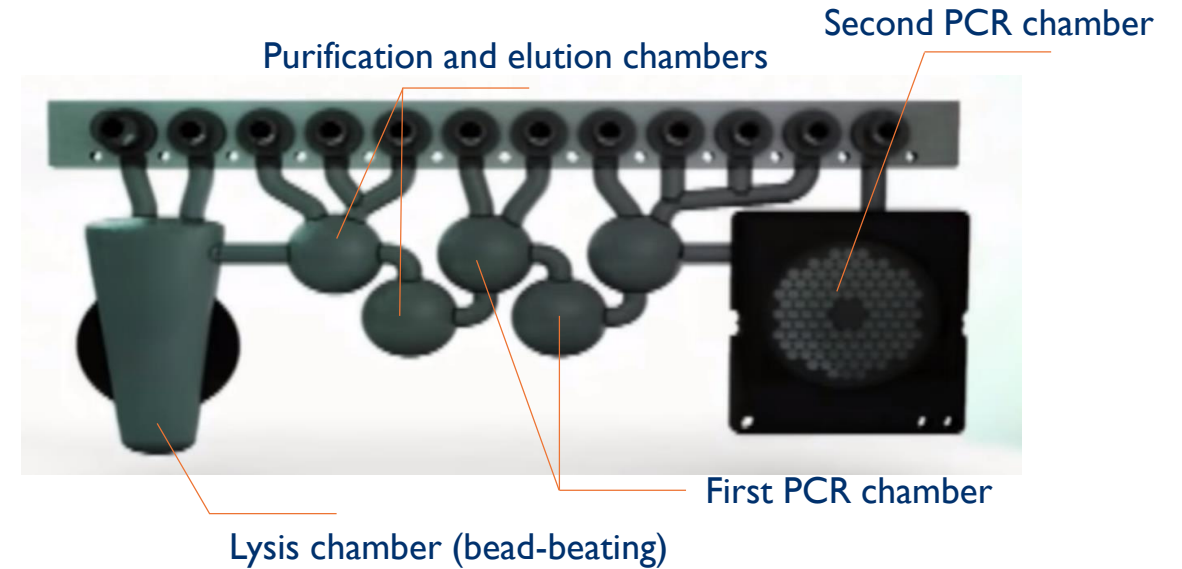
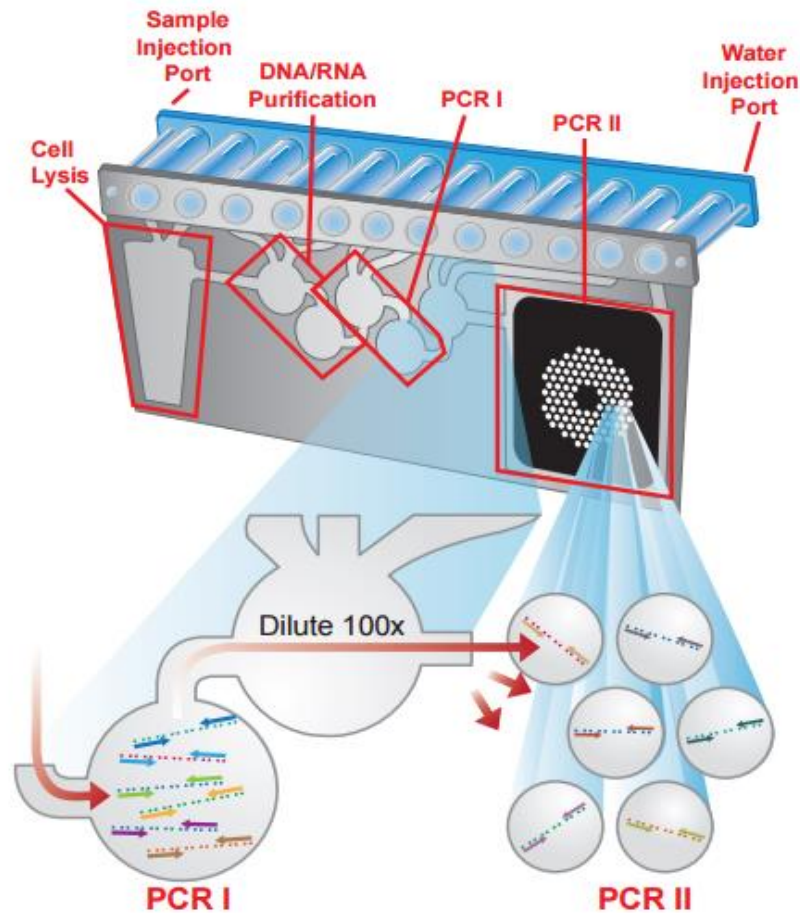


Dot Projector – Opened View

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MICROFLUIDICS TECHNOLOGY TRENDS

An increasing on-chip complexity for ever more integration and automation



Pictures source: BioFire Diagnostics

AS A CONCLUSION...

- The photonic industry is just incredibly fragmented, in term of technologies, products, companies...
- No single convergence is visible
- The growth is coming from each single markets and applications, but also in the ability to integrate at the right level the functions of light emission, light management, control and sensing
- The availability of light sources in different format, wavelength, output power and at low enough price is pushing a lot of applications:
 - Lidar, 3D sensing, Si Photonics, gas sensing, particle detection...
- In addition, the availability of manufacturing infrastructure for Si Photonics is also making simpler (not simple...) the integration of multiple optical functions in the same:
 - Package, Module, Shoe box
- So we see at Yole multiple growth opportunities to make incredible products, from consumer applications to cars, industrial and high end applications

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