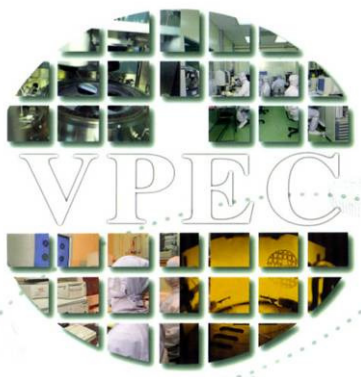




Company Profile

World-class leading edge with MOCVD





Safe Harbor Notice

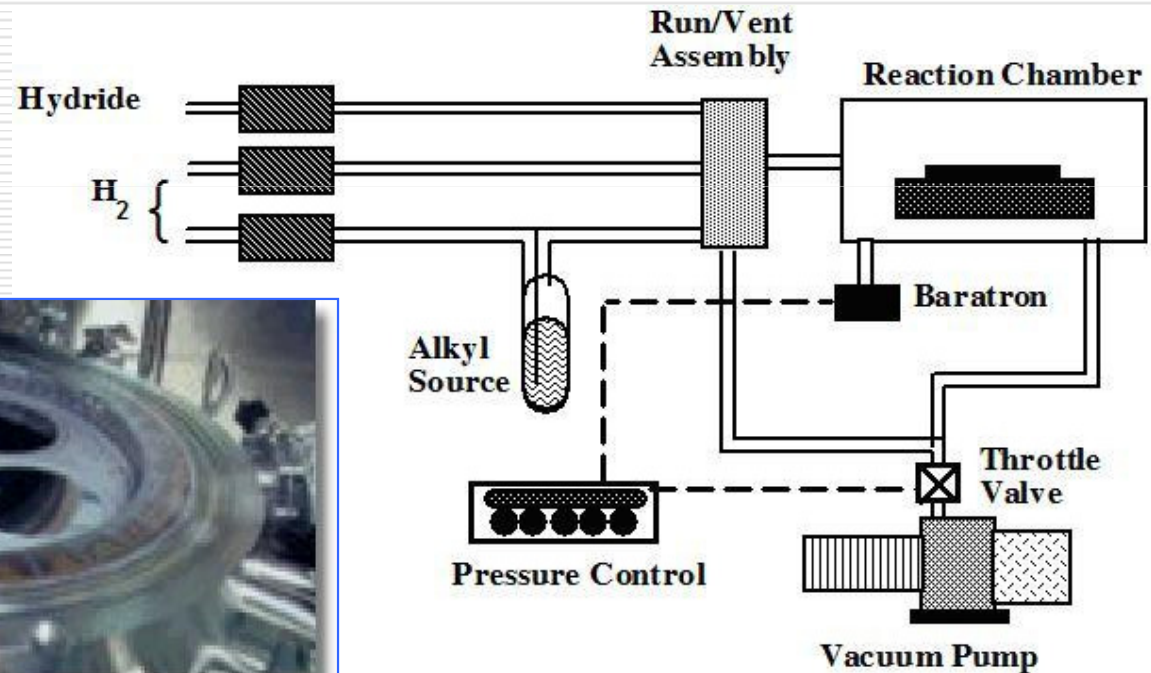
- *This presentation contains certain forward-looking statements that are based on current expectations and are subject to known and unknown risks and uncertainties that could cause actual results to differ materially from those expressed or implied by such statements.*
- *Except as required by law, we undertake no obligation to update any forward-looking statements, whether as a result of new information, future events or otherwise.*



Core Technology

MOCVD (有機金屬氣相沉積法)

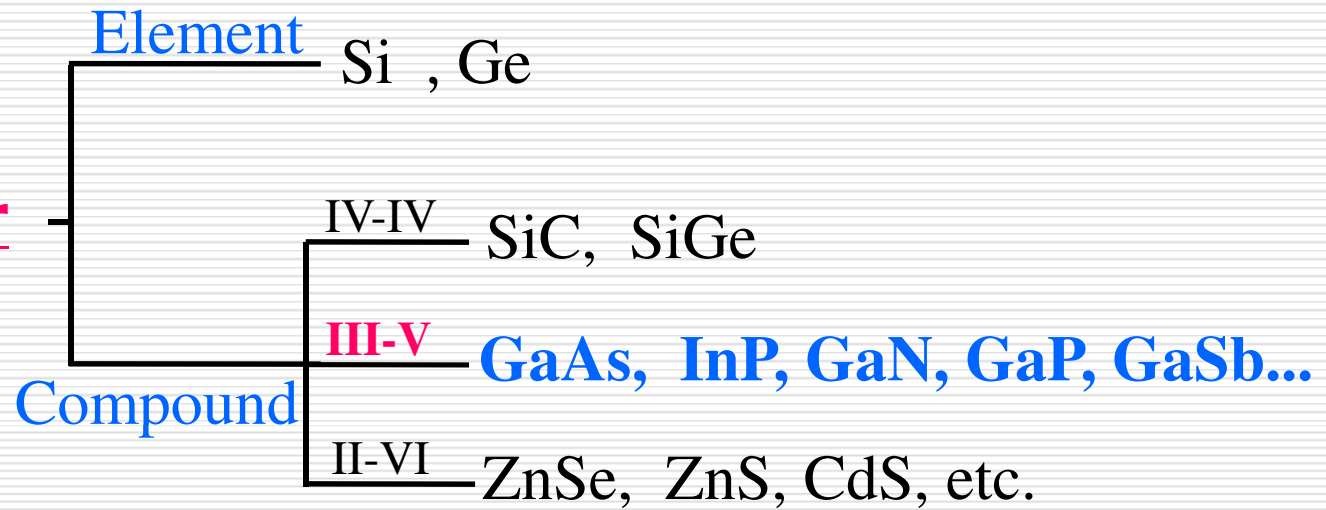
- Metal Organic Chemical Vapor Deposition





Semiconductor (by Material)

Semiconductor



Period	Column II	III	IV	V	VI
2	Be 鈹 Beryllium	B 硼 Boron	C 碳 Carbon	N 氮 Nitrogen	O 氧 Oxygen
3	Mg 鎂 Magnesium	Al 鋁 Aluminum	Si 矽 Silicon	P 磷 Phosphorus	S 硫 Sulfur
4	Zn 鋅 Zinc	Ga 鎵 Gallium	Ge 鍺 Germanium	As 砷 Arsenic	Se 硒 Selenium
5	Cd 鎘 Cadmium	In 銦 Indium	Sn 錫 Tin	Sb 銻 Antimony	Te 碲 Tellurium
6	Hg 汞 Mercury	Tl 鉍 Thallium	Pb 鉛 Lead		

二元化合物 Binary : GaAs, InP, GaP, GaN, etc.

三元化合物 Ternary : InGaAs, InGaP, AlGaAs, etc.

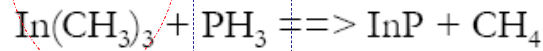
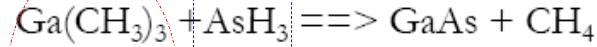
四元化合物 Quaternary : AlGaInP, InGaAsP, etc.

五元化合物 Pentanary : AlGaInAsN, etc.



Chemical Reaction During Epitaxy

化學反應式：

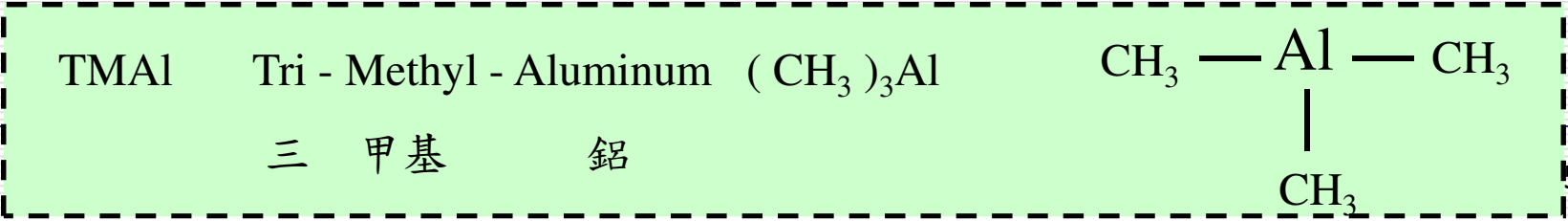


主要原物料：

MO Source + **Hydride** + Carrier Gas : **H₂**

TEAl : Tri-ethyl-Aluminum (C₂H₅)₃Al
 TMGa : Tri-Methyl-Gallium (CH₃)₃ Ga
 TMIn : Tri-Methyl-Indium (CH₃)₃In
 DETe : Di-ethyl-Tellurium (C₂H₅)₂Te
 DEZn : Di-ethyl-Zinc (C₂H₅)₂Zn
 CP₂Mg : Bis (cyclo-penta-dienyl) Magnesium 環戊二烯鎂

AsH₃ : Arsine
 PH₃ : Phosphine
 SiH₄ : Silane
 Si₂H₆ : Disilane
 H₂Se : Hydrogen Selenide
 CBr₄ : Carbon Tetrabromide





Advantages of Compound Semiconductor

1. High Electron Mobility 高電子移動速率 (5.7x higher than CMOS)
2. High Frequency Response 高頻率響應
3. Wide Band Width 寬幅之頻寬
4. High Linearity 高線性度
5. High Power 高功率
6. Alternative Choice of Material 材料選擇多元性
7. 抗輻射

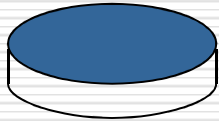
適用於無線通訊、光纖通訊、光顯示(LED)& 太陽能產業



GaAs in Wireless Communication Supply Chain

Sumitomo, Freiberg, AXT

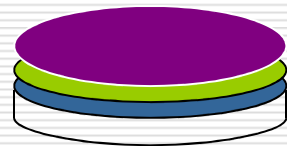
4~6 " GaAs Substrate



GaAs Epi- Wafer
磊晶片

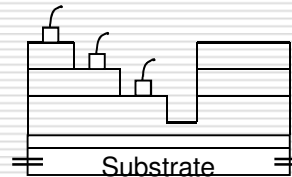
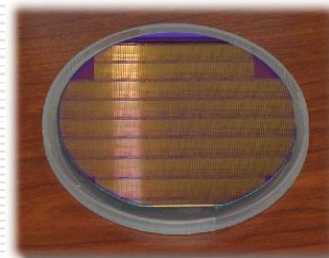


MOCVD Reactor



IDM: Skyworks, Qorvo,
Avago, Anadigics

Microelectronics
IC Process

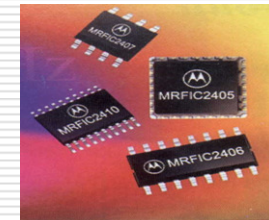


Foundry:

WIN, AWSC,
GCS



Wireless
Communication

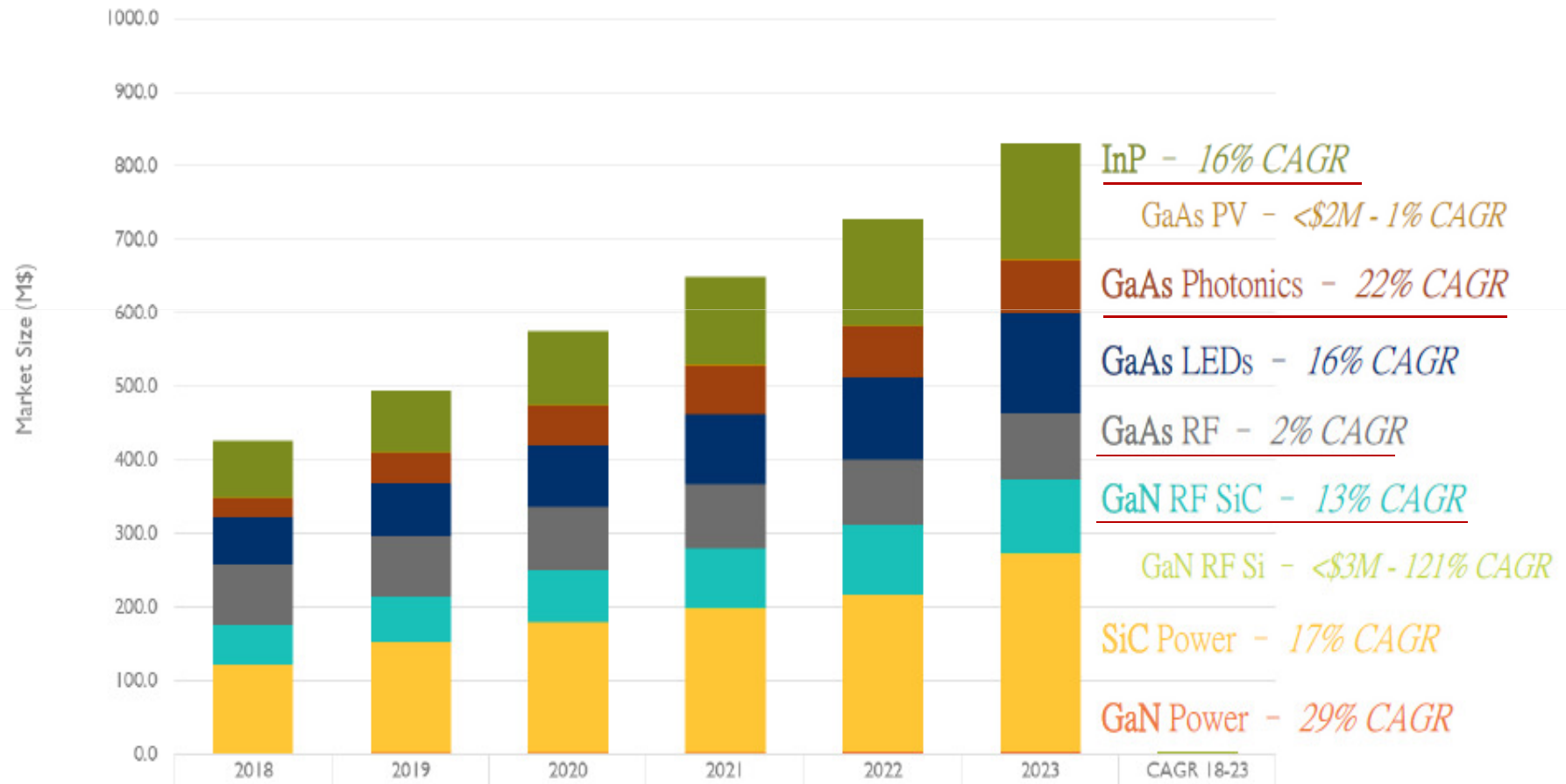


IC Package & Testing



Market Size Forecast

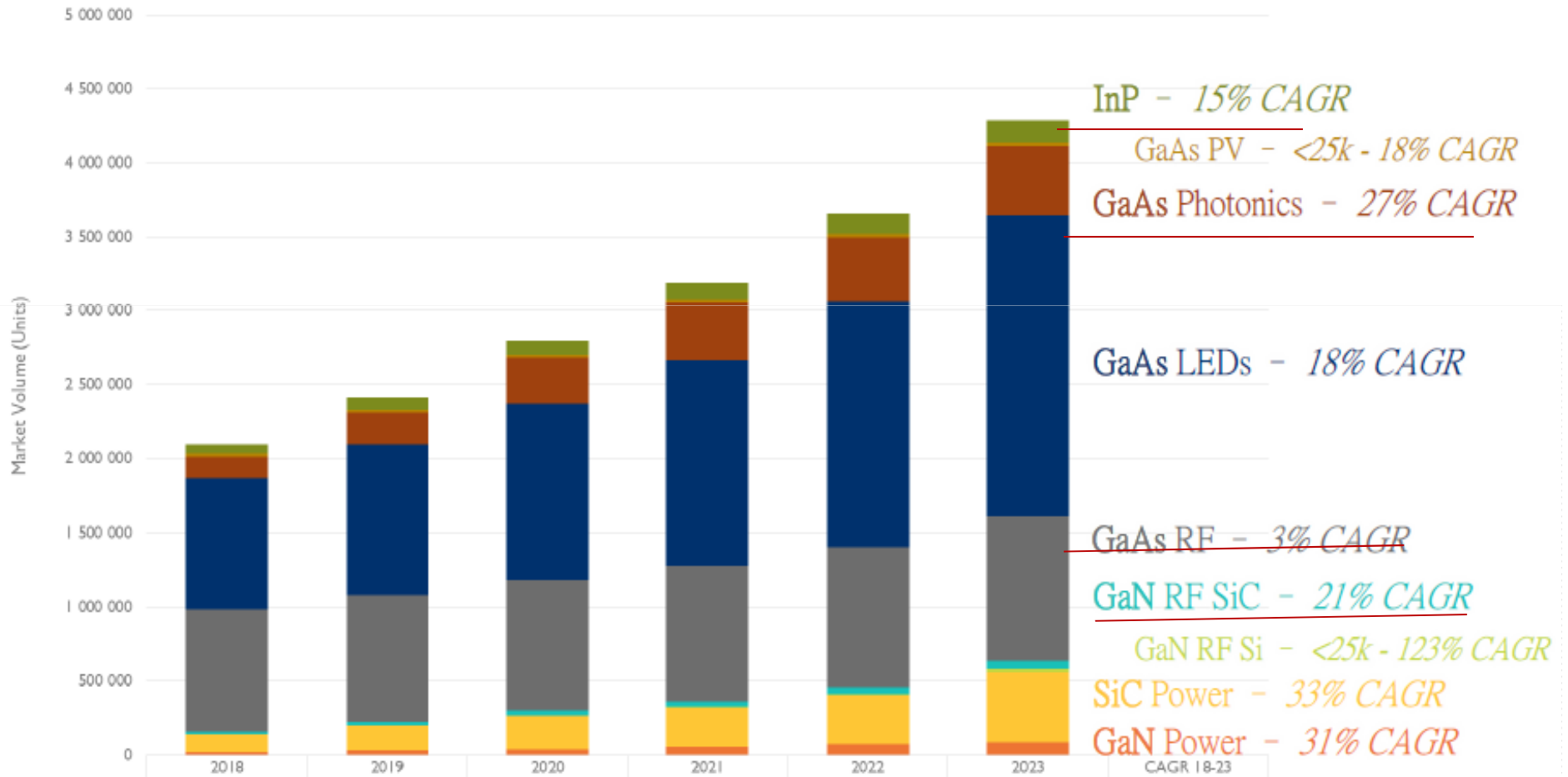
Compound Semiconductor Wafer Market Size (2018-2023)





Market Size Forecast

Compound Semiconductor Wafer Market Volume (2018-2023)



Source:Yole 9



VPEC's products

Microelectronics

- **HBT**
- **PHEMT**
- **BiHEMT**
- **GaN on SiC**

Photonics

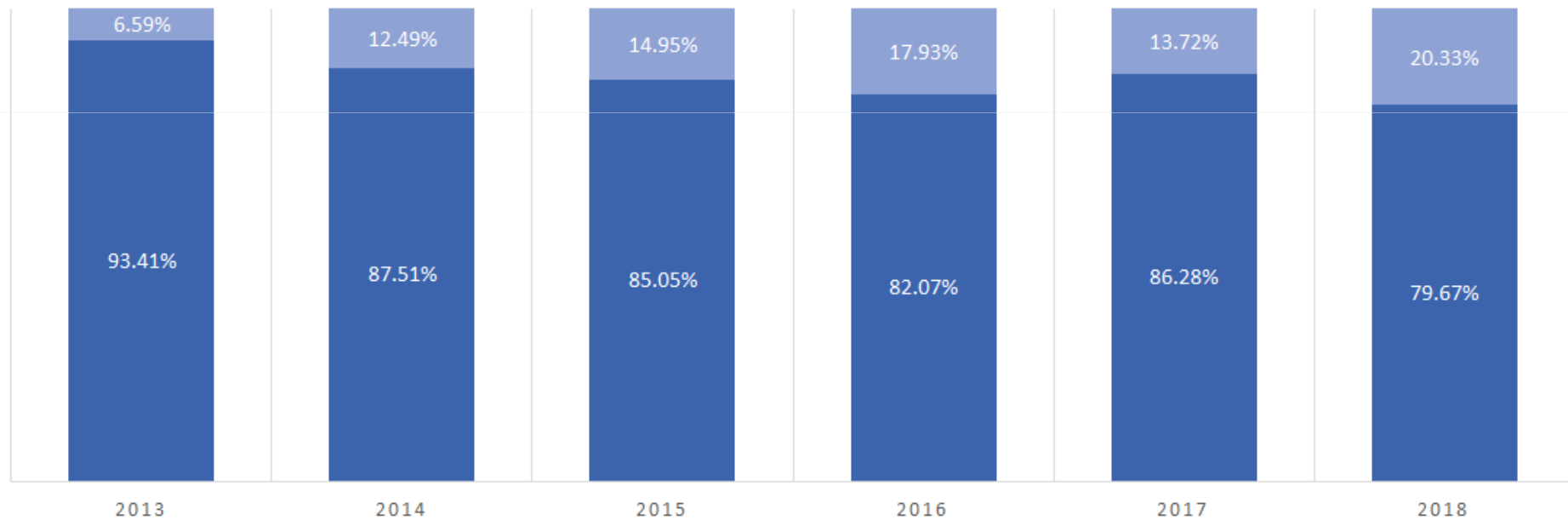
- **LD**
 - **VCSEL**
 - **PD**
-



VPEC's Product Mix

BY YEAR

■ Microelectronics ■ Photonics

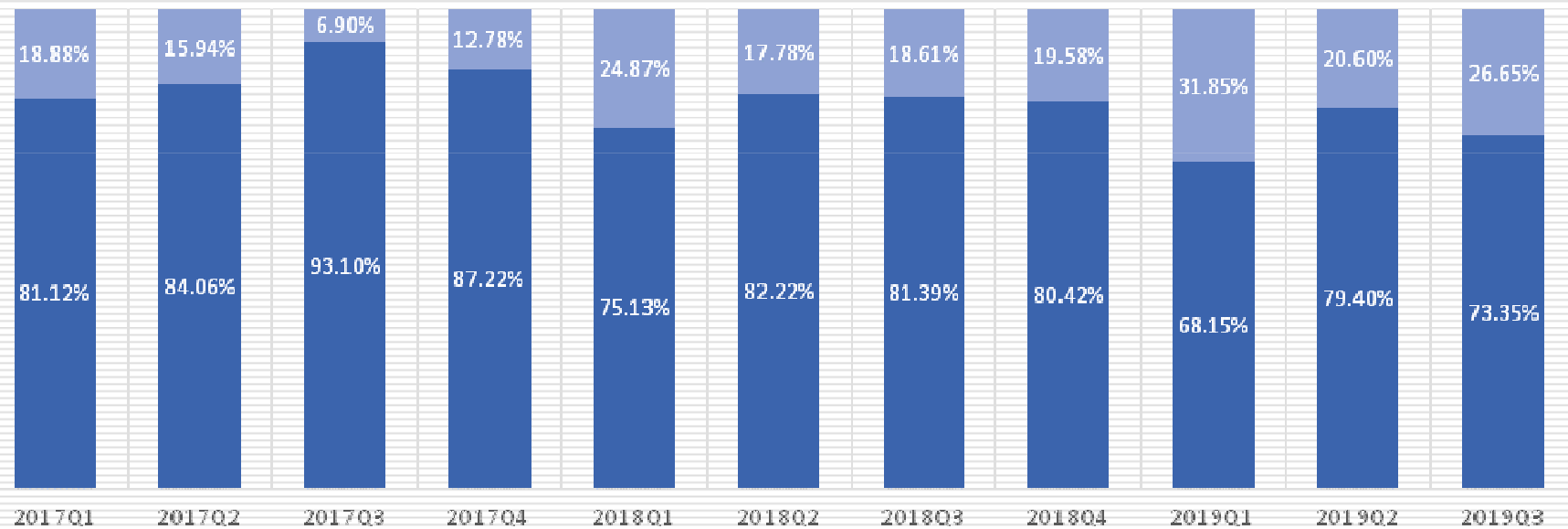




VPEC's Product Mix

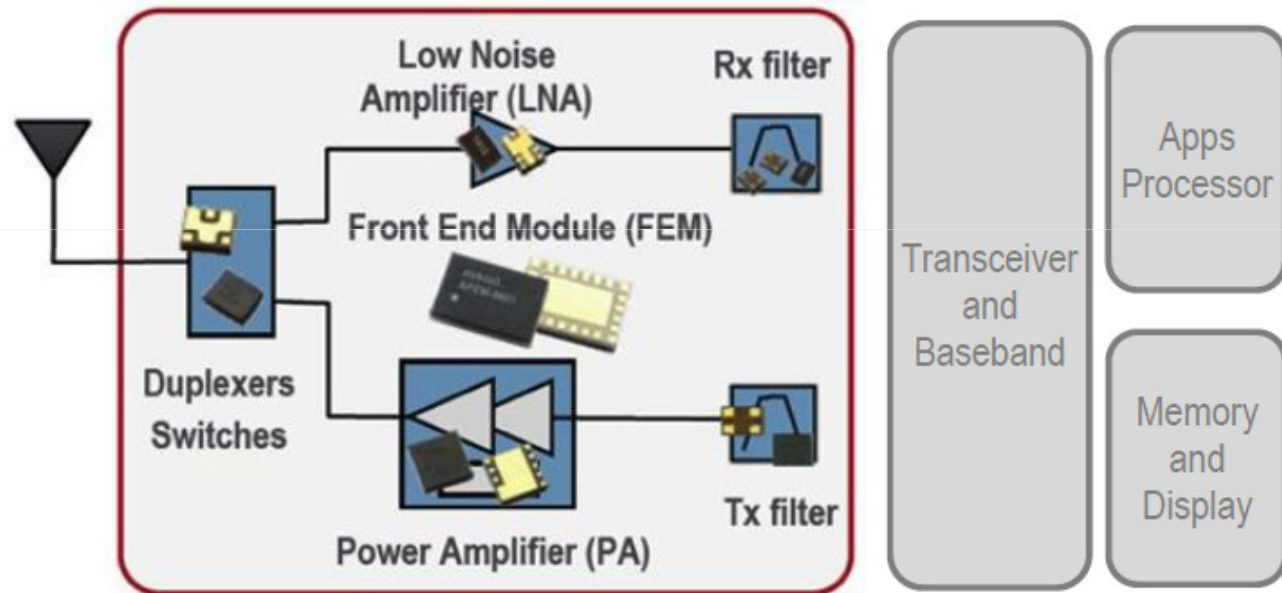
BY QUARTER

■ Microelectronics ■ Photonics





RF



Source:Avago



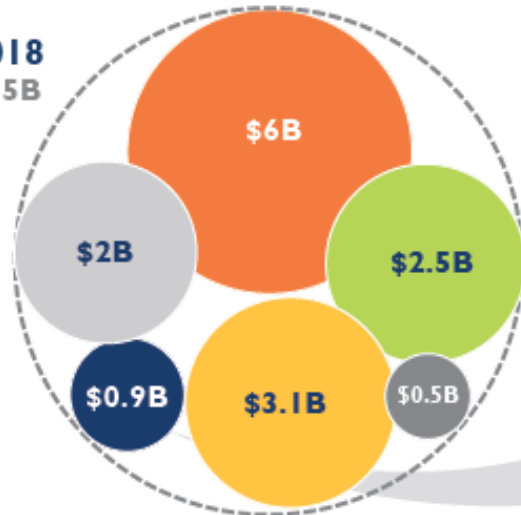
RF Outlook

RF front-end and connectivity market forecast – By component

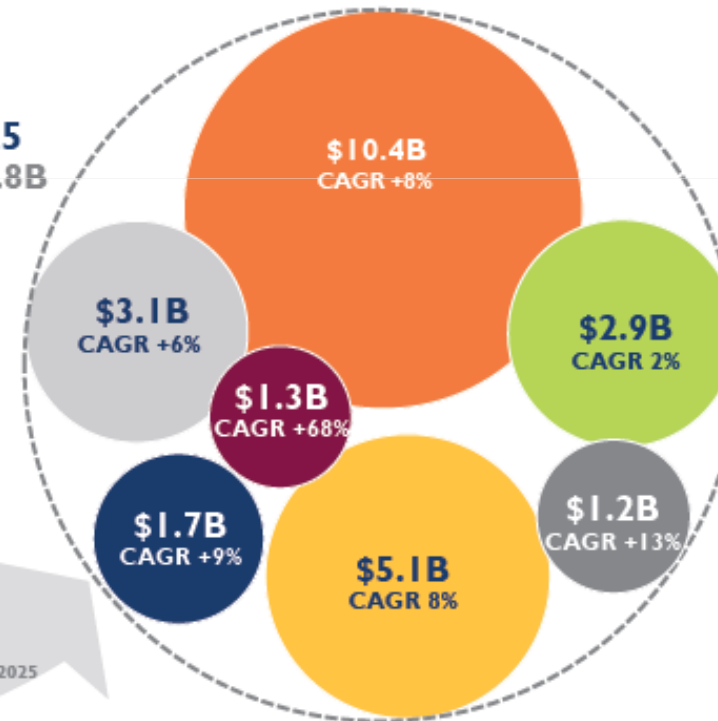
— TAM modules & RF components for front-end and connectivity

- PA module
- Receive module
- Wi-Fi & connectivity module
- AiP module
- Discrete filter, duplexer,...
- Discrete switch & LNA
- Tuner

2018
\$15B



2025
\$25.8B



CAGR 2018-2025
+8%

(Yole Développement, August 2019)



5G Brings New RF Challenges for Handsets

RF complexity

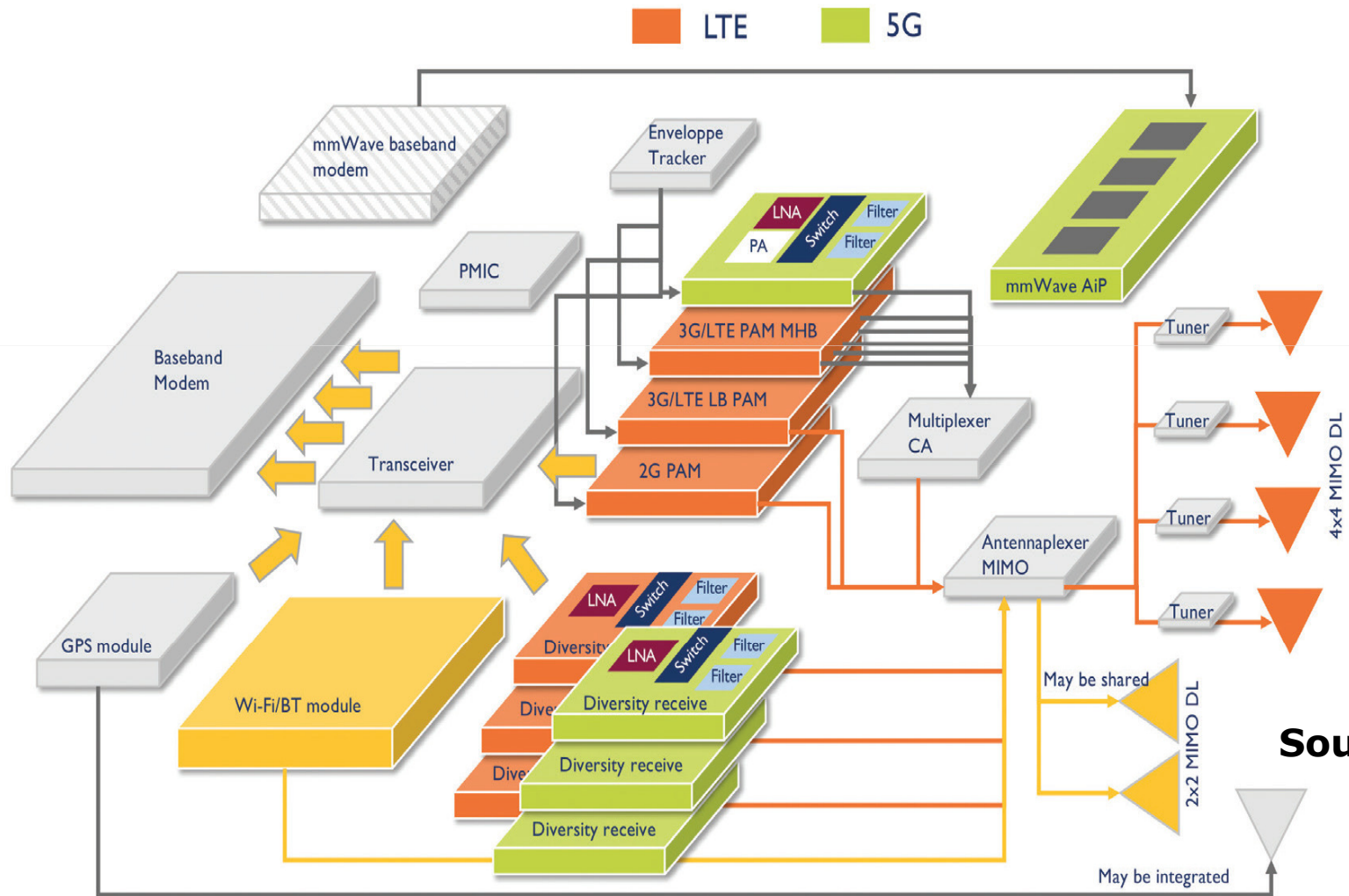
- ◆ **Bandwidth**
- ◆ **Linearity**
- ◆ **Power management**

GaAs Provides The Key Ingredient For 5G Phones





5G Smart Phone RFFM



Source: Yole



Samsung Galaxy

Comparison of major RF-related IC: Samsung Galaxy S10+ and S10 5G

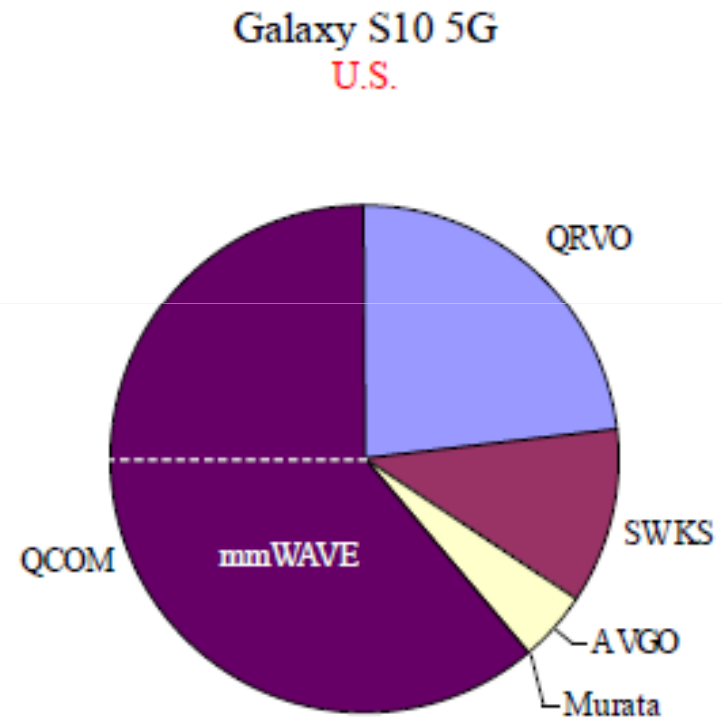
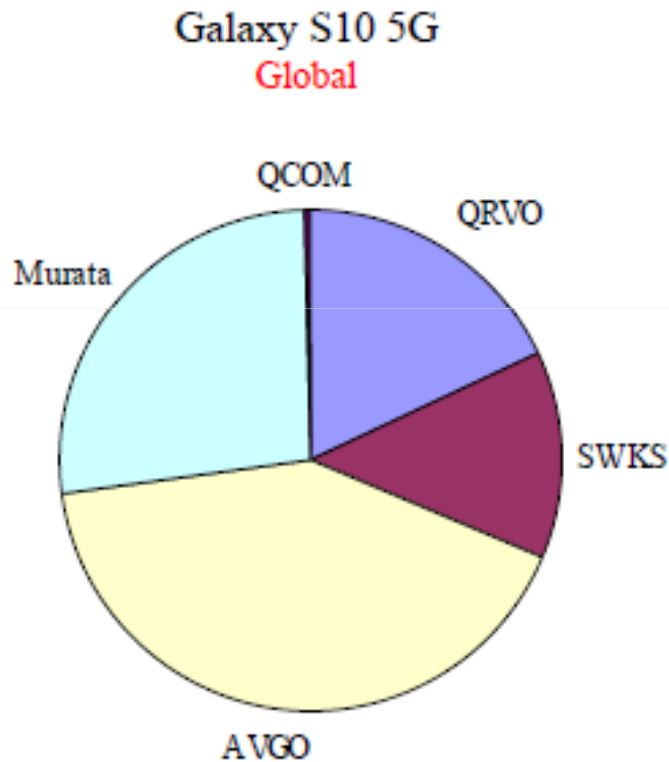
Galaxy S10 Plus (4G)	Galaxy S10 5G (Qualcomm version)	Galaxy S10 5G (Samsung version)
5G modem		
na	Qualcomm X50 5G Modem	Samsung S5T5100 Exynos 5100 5G Modem
RF front-end module (FEM)		
Murata J51 LB FEM	Skyworks 13716-11 LB FEM	Murata J51 LB FEM
Murata 361 LB Diversity FEM	Skyworks 78160-51 LB FEM	Murata 361 LB Diversity FEM
Murata 409 HB/MB Diversity FEM x 2	Skyworks 77365-11 GSM PA	Murata 409 HB/MB Diversity FEM x 2
Skyworks SKY77365-11 GSM PAM	Qorvo QM78062 MB/HB FEM	Skyworks SKY77365-11 GSM PAM
Avago AFEM-9100 HB/MB FEM	Qorvo QM78042 UHB FEM	Avago AFEM-9100 HB/MB FEM
	Qualcomm QDM3870 LTE RF FEM x 2	Qorvo QM78077 FEM
Other RF-related IC/module		
Samsung Shannon 5500 RF Tranceiver	Qorvo QM13124 RF Antenna Tuner	Samsung Shannon 5500 RF Tranceiver x 2
Broadcom BCM47752 GNSS Receiver	Qualcomm SDR8150 RF Transceiver	Broadcom BCM47752 GNSS Receiver
Samsung Shannon 760 Envelope Tracking Power Supply	Qualcomm QET5100 Power Envelope Tracker x 2	FCI FC8080 RF Tuner & Demodulator
		Samsung Exynos SM 5800 Supply Modulator
PMIC		
Samsung Shannon 5200 PMIC	Qualcomm PMX50 PMIC (for X50 Modem)	Samsung Shannon 5200 PMIC
Samsung Shannon 5201 PMIC	Qualcomm PM8150 PMIC	Samsung Shannon 5201 PMIC
Maxim MAX77705C PMIC	Qualcomm PM8150C PMIC	Samsung Shannon 5310 PMIC
	Qualcomm PM8005 PMIC	Maxim MAX77705C PMIC
	Maxim MAX77705C PMIC	

Source: iFixit, Tech Insights, Nomura research



RF Players in Galaxy S10 (Global VS. U.S.)

QCOM: Modem win drives RF, most of which is mmWave





Huawei

Mate20x 5G; RF BOM cost \$32~35

Qorvo (QM77031) MB/HB

Qorvo envelope tracker (RF 8129)

Skyworks LB (78191)

HiSilicon MB/HB PAMID (Hi6D03)x2

HiSilicon LNA/RF switch (Hi6H11/12)x6

Mate30 Pro 5G; RF BOM cost \$32~35

Murata 5G RFFE

Murata MB/HB RFFE

HiSilicon MB/HB RFFE

Maxscend antenna tuner

Skyworks antenna tuner

Qorvo antenna tuner

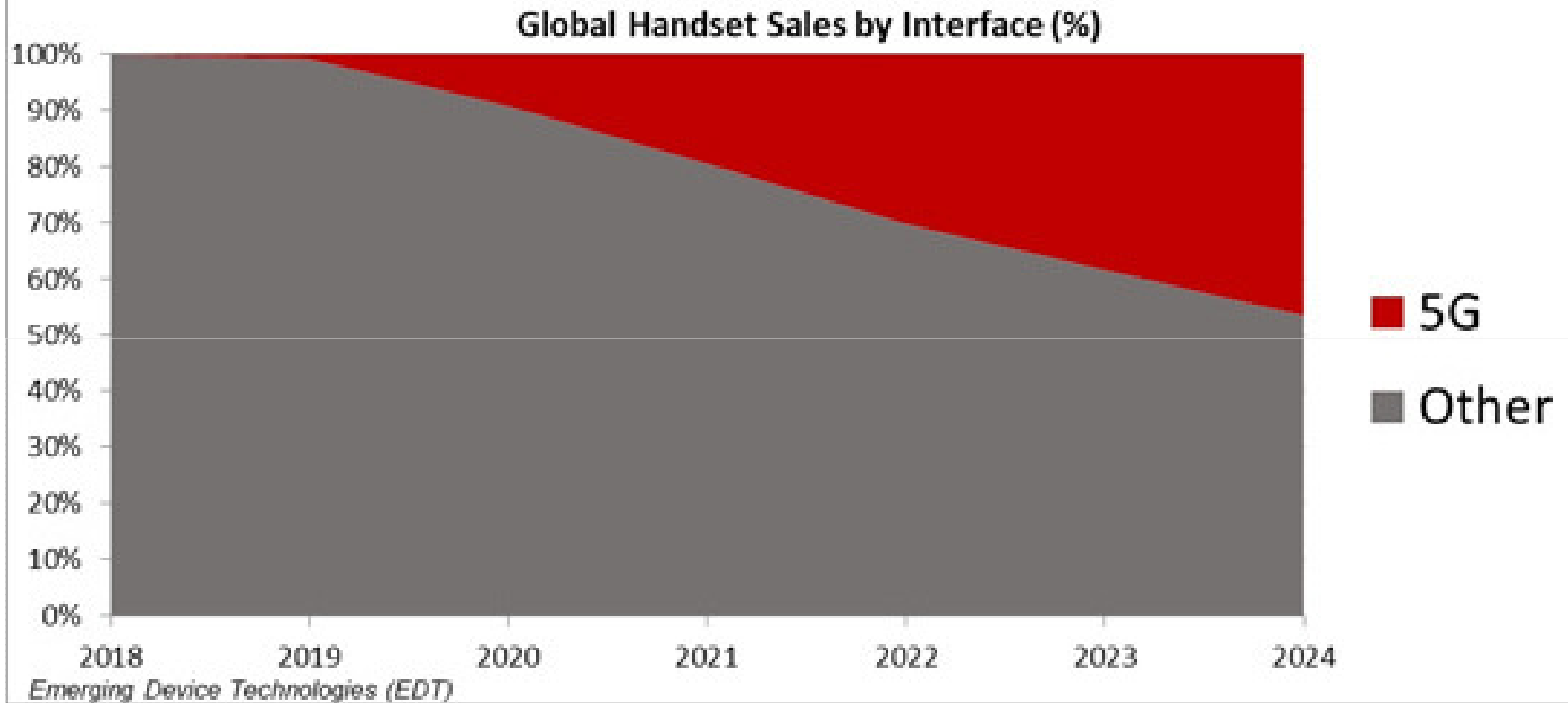
Source: ifixit, Techinsights, IHS, Fubon Research

- 1) HiSilicon's 5G SoC has effectively 65-70% bigger die size than its 4G one;
- 2) Skyworks and Qorvo's RF modules are totally displaced by HiSilicon, Murata, and Qualcomm;
- 3) Murata has the most RF content wins;
- 4) MediaTek is displacing Qorvo in Envelop Tracking IC; 5) HiSilicon makes the majority of PMIC, but there are two new Chinese suppliers; and 6) DRAM in flagship 5G is the same as 4G.

Source: CLSA



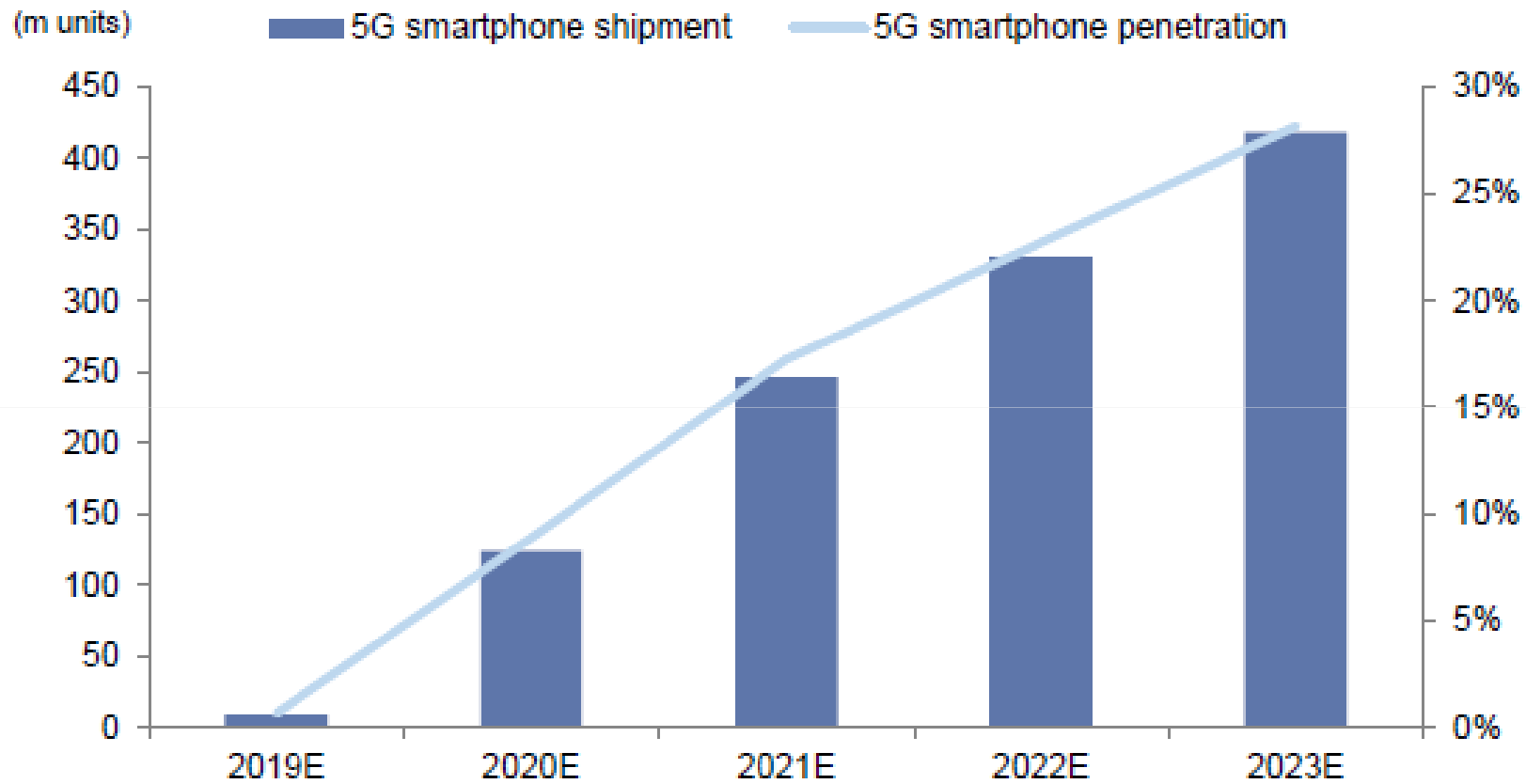
5G Smart Phone's Penetration Rate



Strategy Analytics estimates that less than 1% of phones sold in 2019 will be 5G devices, but that share will grow to nearly 10% in 2020. "



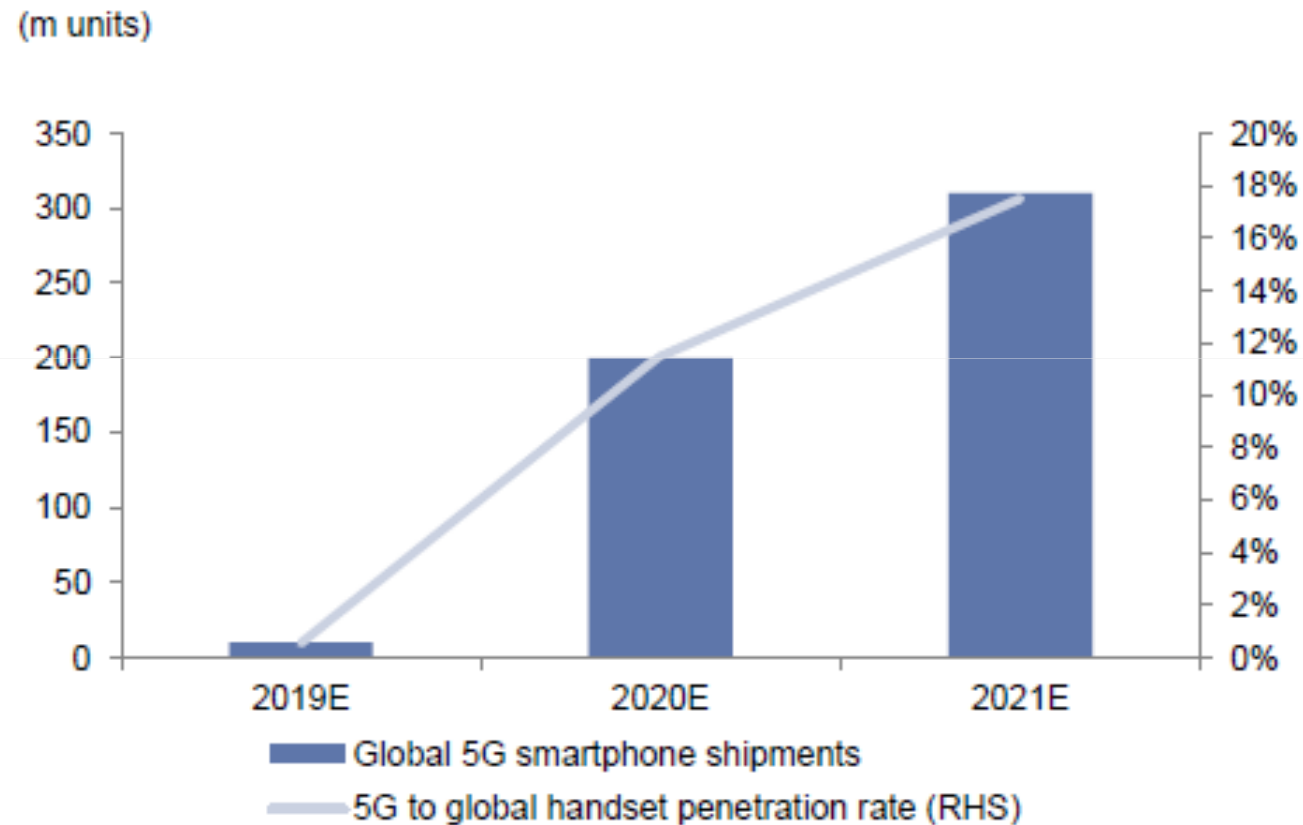
5G Smart Phone Shipments



Source: IDC



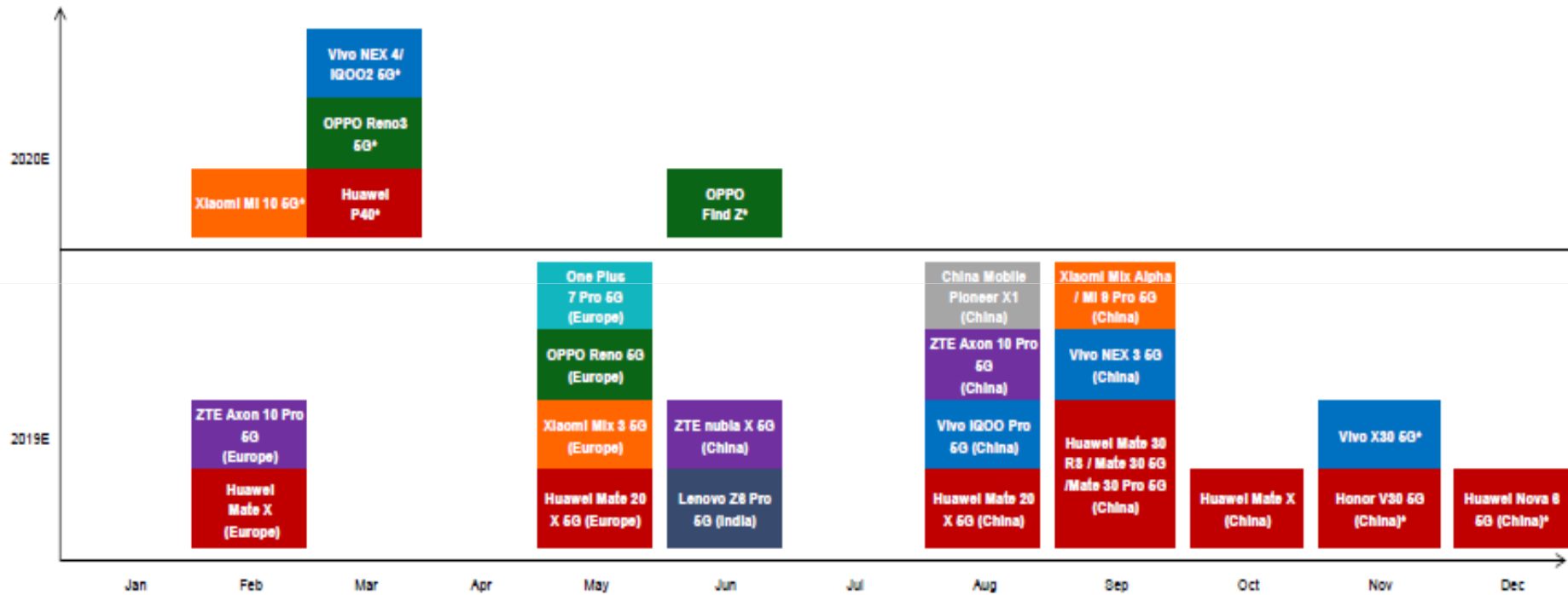
5G Smart Phone Shipments



Source: Goldman Sachs Global Investment Research



Chinese Brands' 5G Smartphone Roadmap

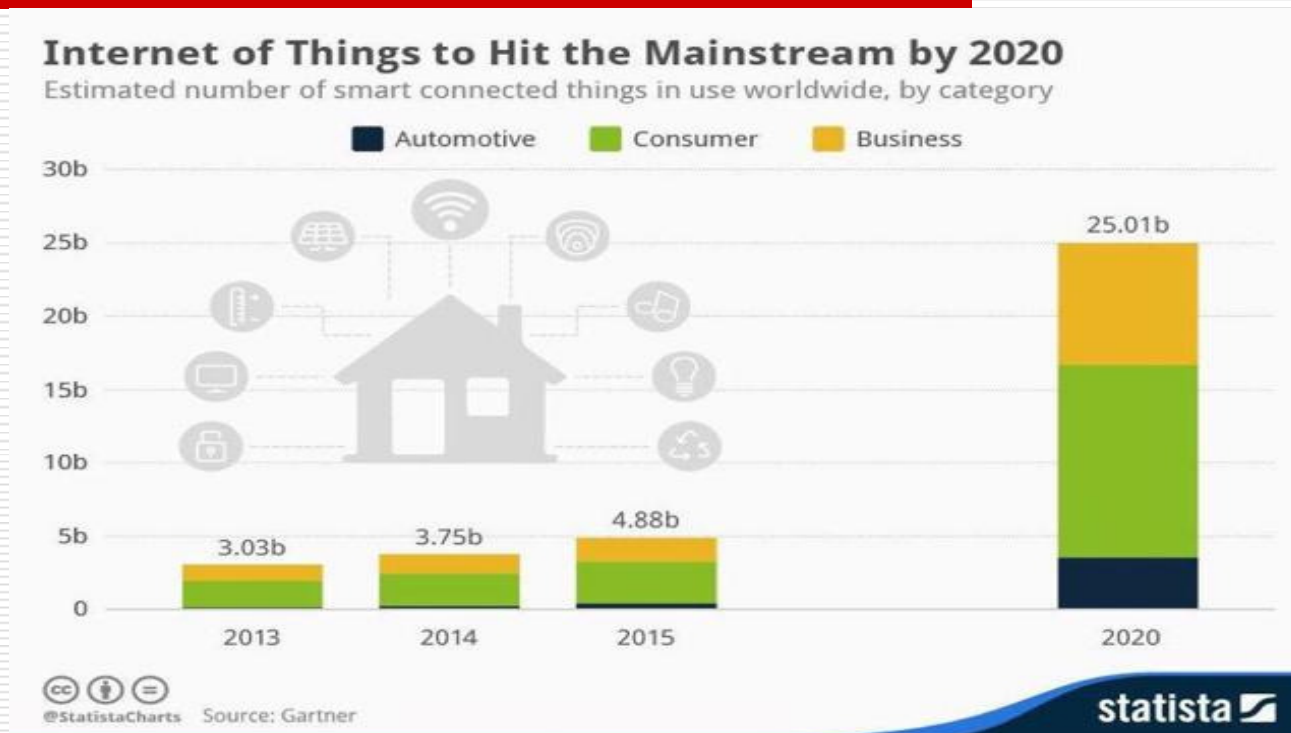


* Expected model and launch date

Source: Company data, Goldman Sachs Global Investment Research



IoT(802.11ac/802.11ax/802.11ad)



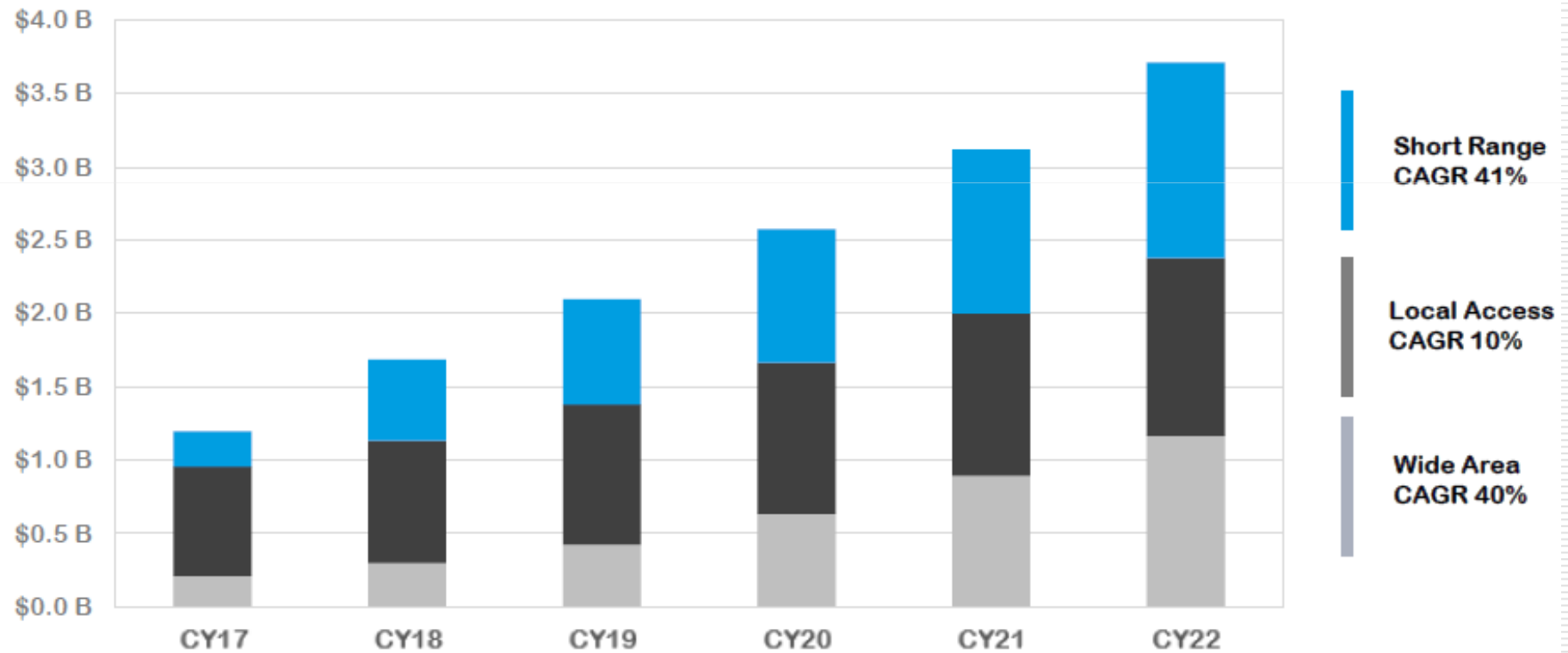
802.11ax will greatly increase network capacity by supporting up to eight simultaneous data streams, each delivering up to 1.2 Gbps, to connect many more devices at greater speeds. 802.11ax portfolio includes 2.4GHz and 5GHz front-end modules (FEMs) and BAW filters. According to ABI Research estimates, Wi-Fi 6 chipset shipments are expected to grow from approximately 127 million units in 2019 to close to 2 billion units by 2024, representing a compounded annual growth rate of approximately 73 percent.



IoT RF Opportunity

IoT RF Opportunity

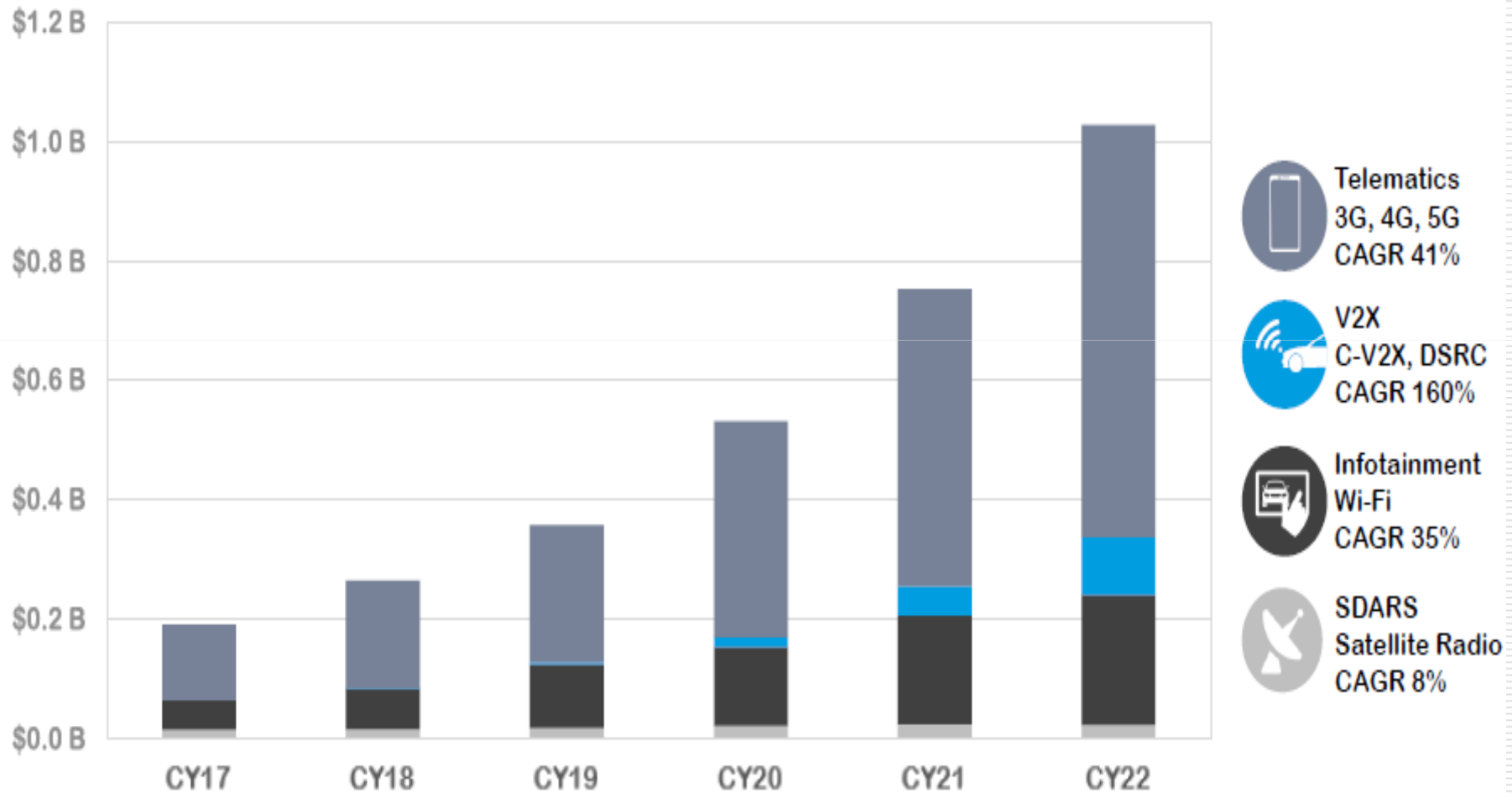
Strong growth across multiple market segments



Source: Qorvo and Industry Estimates



RF in Automobile



Source: Qorvo and Industry Estimates



RF in Automobile

The Connected Car

Pacing Toward 2020+ Opportunity



- Complete 5G System Architecture
- Tx/Rx
 - DRx
 - MIMO
 - Antenna Tuning
 - WiFi / Bluetooth
 - Low, Mid, High Band
 - Legacy 4G and New Sub 6GHz NR Bands

\$15-20 Opportunity

Delivering 5G Low Latency, High Bandwidth Solutions
Ushering in the Next Generation of Autonomous Vehicles

Source: Skyworks

Gartner Research estimates there will be 250 million connected vehicles on the roadways by 2020.

The Qualcomm 9150 chipset, with the Qorvo QPF1002Q FEM, is currently part of C-V2X trials underway with Audi, PSA, Ford, Nissan and other ecosystem participants spanning projects in Europe, North America, China, Japan, and Korea.

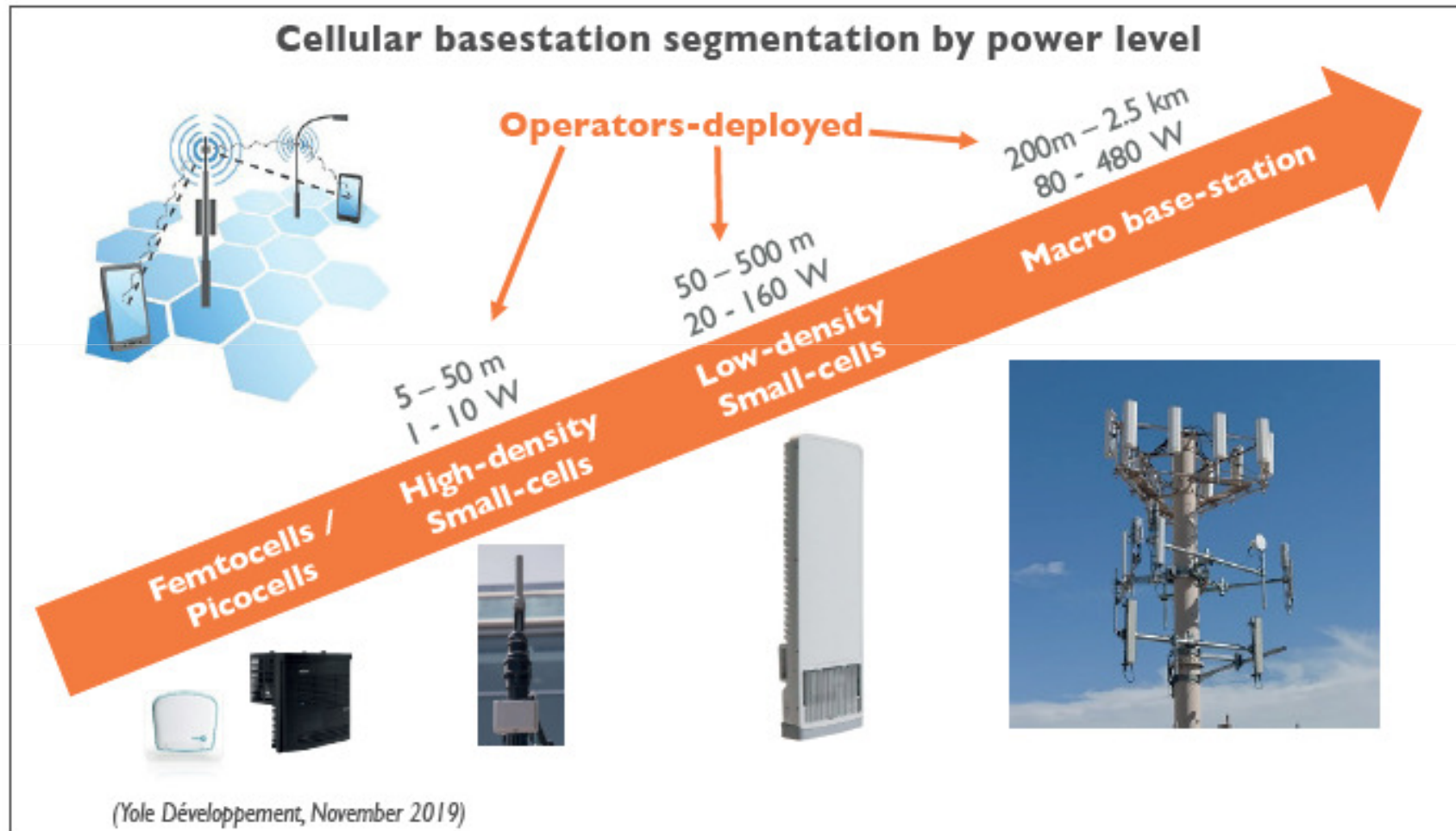
Qorvo's QPF1002Q providing higher linear output power and improved efficiency for lower temperature operation in automotive applications.

This higher power operation results in enhanced range, improved accuracy and higher reliability essential to intelligent, onboard communication systems needed for the connected car and autonomous driving. Qorvo's FEM includes an HBT PA, PHEMT LNA and PHEMT switch, which combine to enable superior performance over competing technologies.

Source: Qorvo

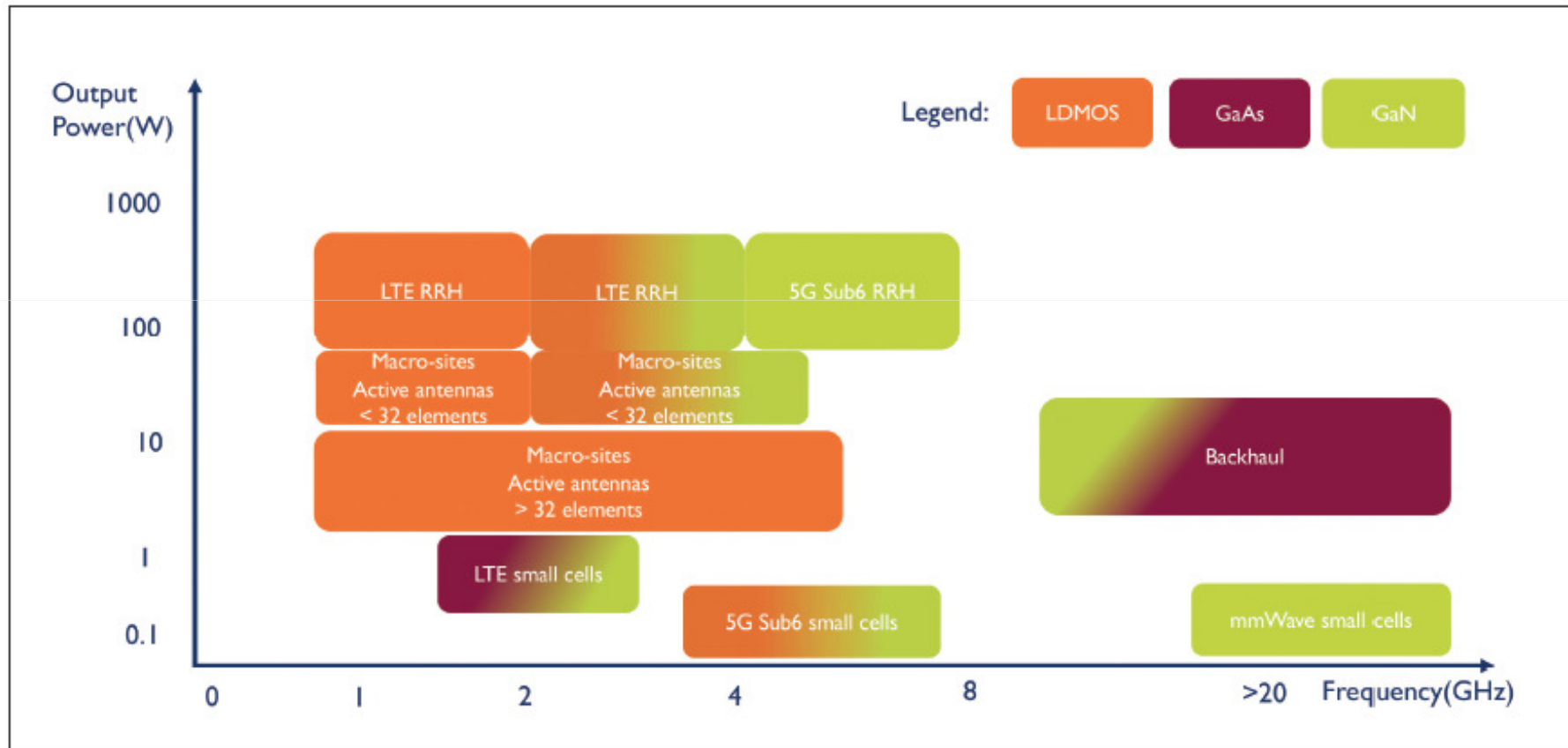


Basestation by Power Level





Infrastructure PA Technology Landscape in 2019





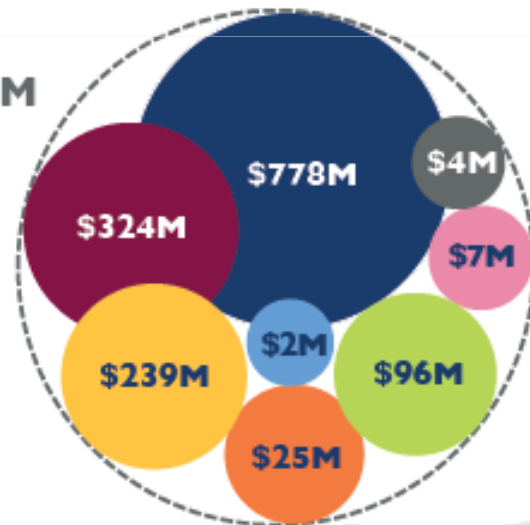
Infrastructure RF Market

2018-2025 Infrastructure RF front end market forecast
Split by technology platform

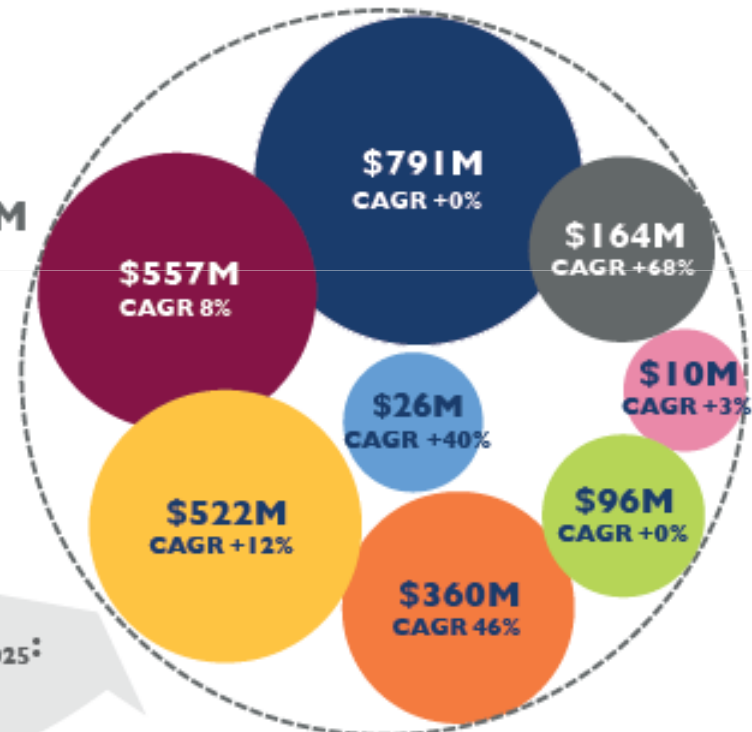
- TAM RF front end
- LDMOS
- GaAs pHEMT
- GaN HEMT
- InGaP HBT

- SiGe BiCMOS
- PIN diode
- RF-SOI
- RF-SOS

2018
\$1,477M



2025
\$2,525M



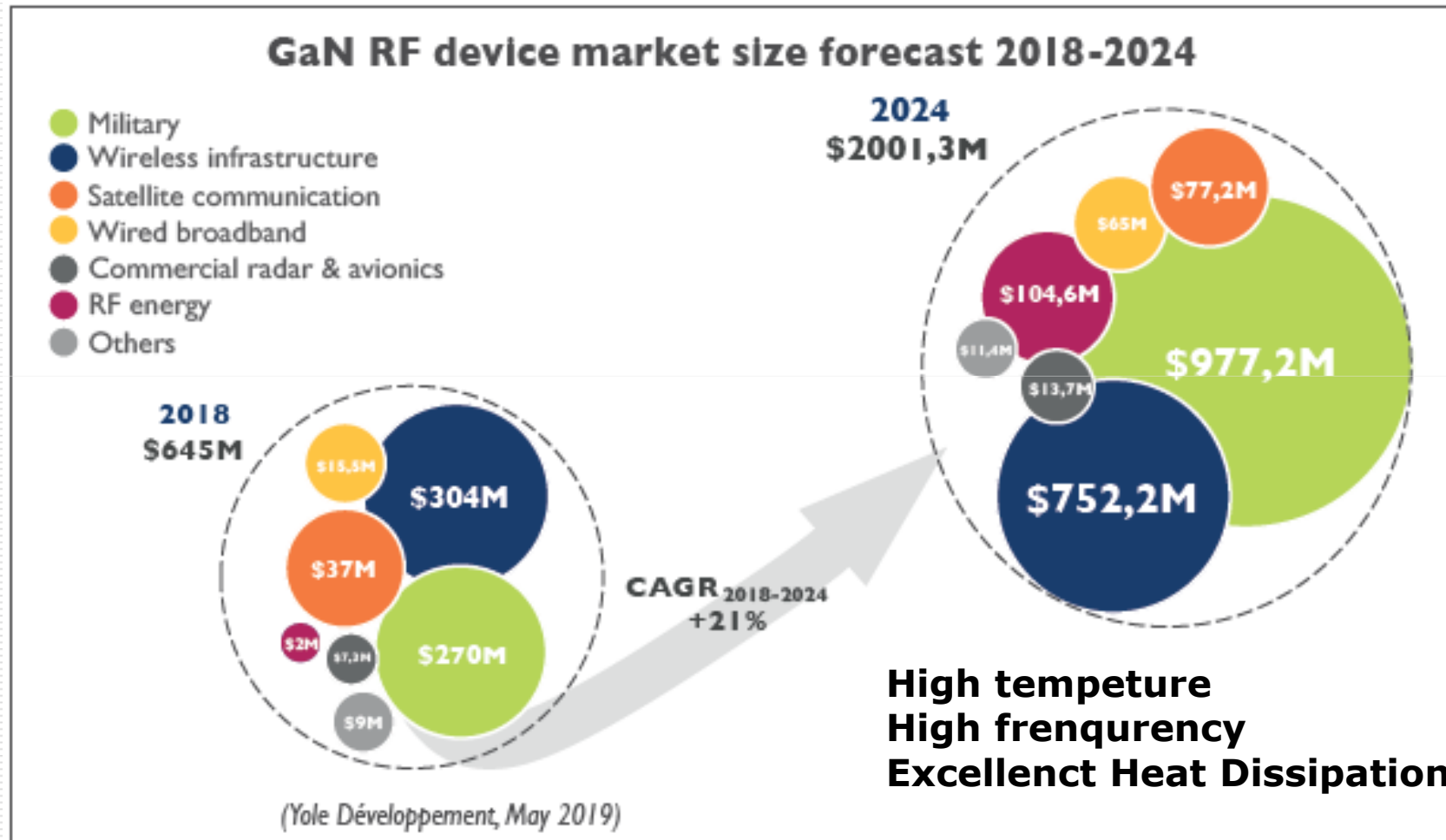
CAGR₂₀₁₈₋₂₀₂₅:
+8%

RF-CMOS remains < \$1M

(Yole Développement, November 2019)



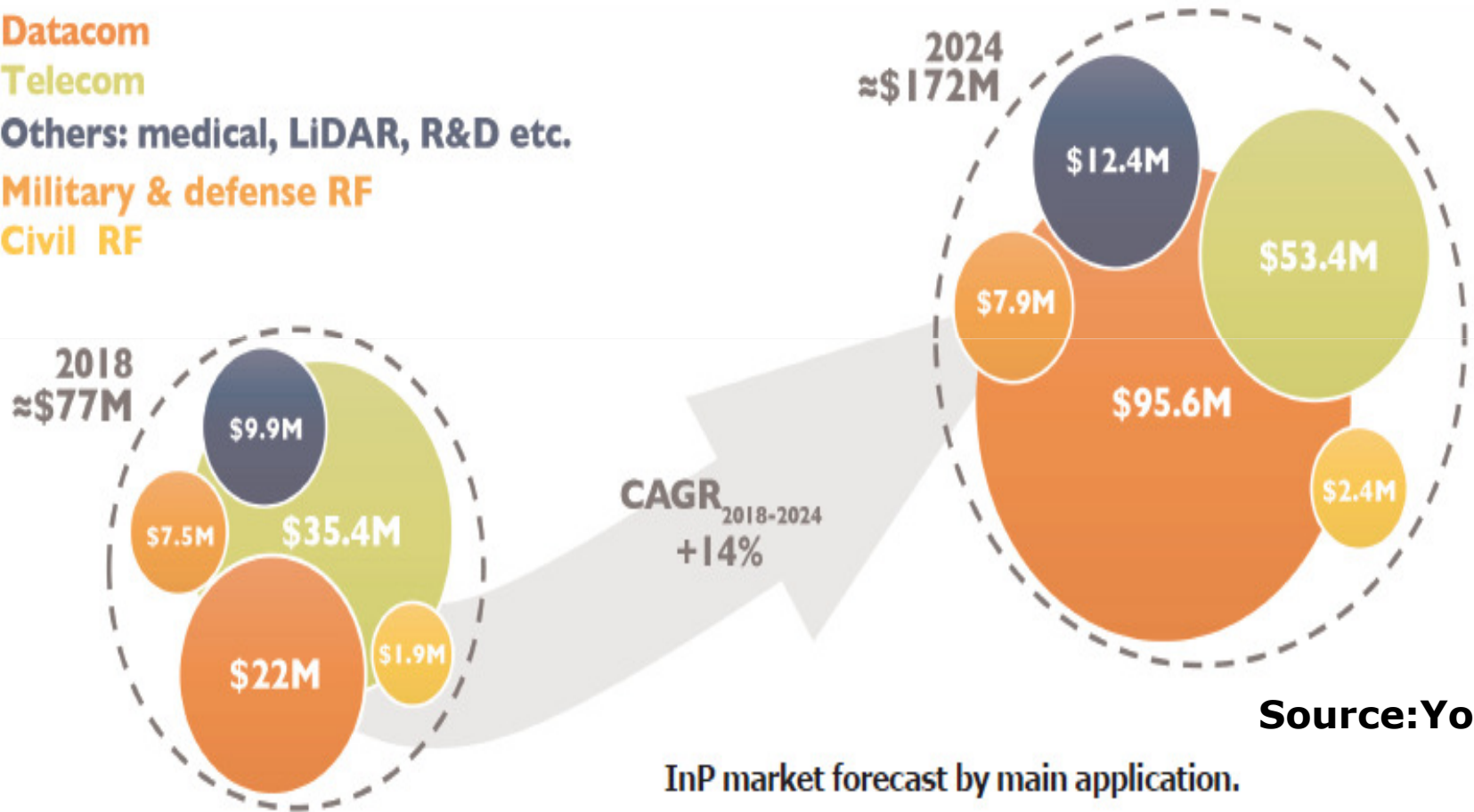
GaN on SiC





InP Market Forecast

- **Datacom**
- **Telecom**
- **Others: medical, LiDAR, R&D etc.**
- **Military & defense RF**
- **Civil RF**

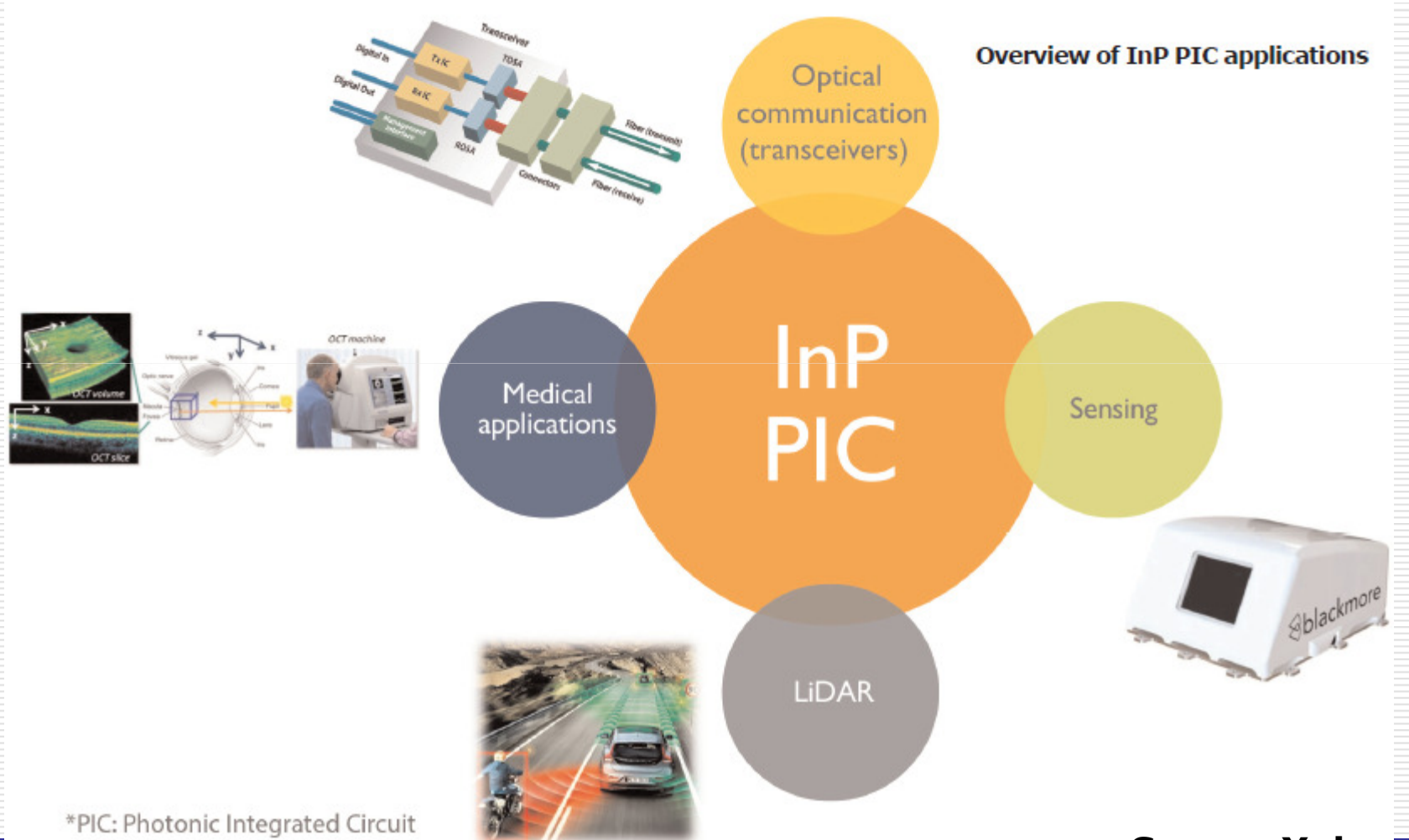


Source: Yole

InP market forecast by main application.



InP Application



Overview of InP PIC applications

*PIC: Photonic Integrated Circuit

Source: Yole



FP LD & DFB LD

- 1270 nm/1310 nm/1550 nm**
- FP LD 2016/11 small volume shipment**
- DFB LD 2018 Q2 small volume shipment**
- Upgraded products in reliability test process**
- Product Advantage:**
 - Far field angle design**
 - Increase power & yield rate**
 - Reduce lens cost**
- Improve product mix & margin**

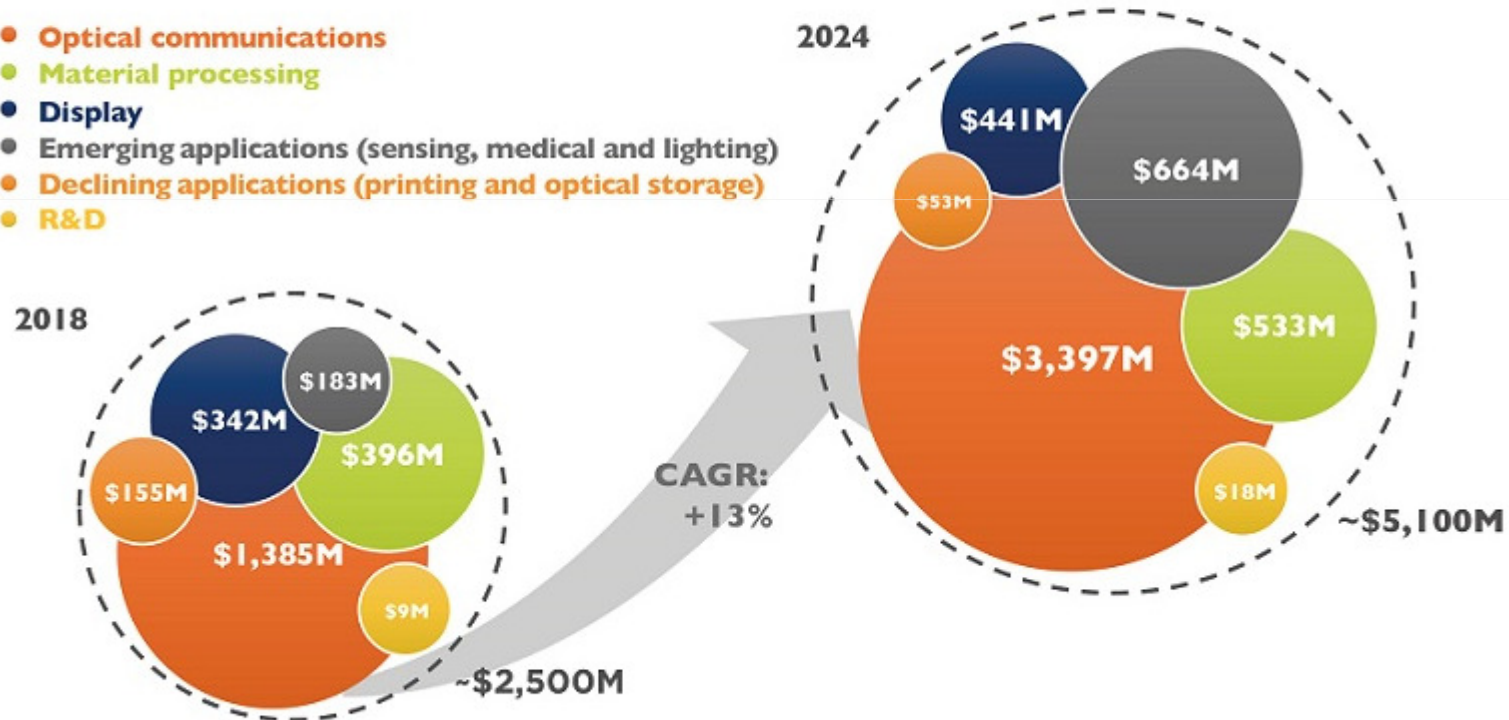


EEL Market Size

Edge Emitting Lasers (EEL) revenue forecast by market segment 2018 vs. 2024

(Source: Edge Emitting Lasers - Market and Technology Trends 2019 report, Yole Développement, 2018)

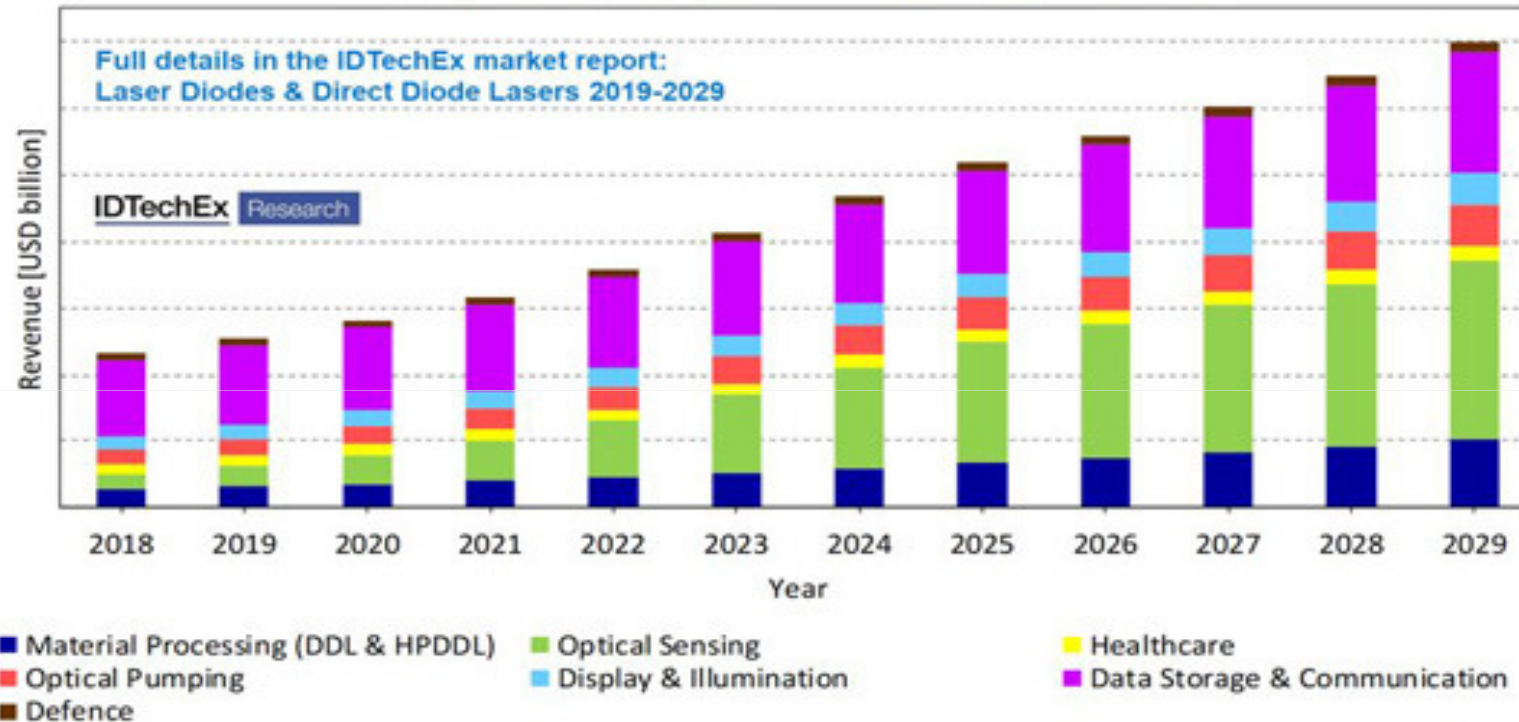
- Optical communications
- Material processing
- Display
- Emerging applications (sensing, medical and lighting)
- Declining applications (printing and optical storage)
- R&D





LD Market Forecast

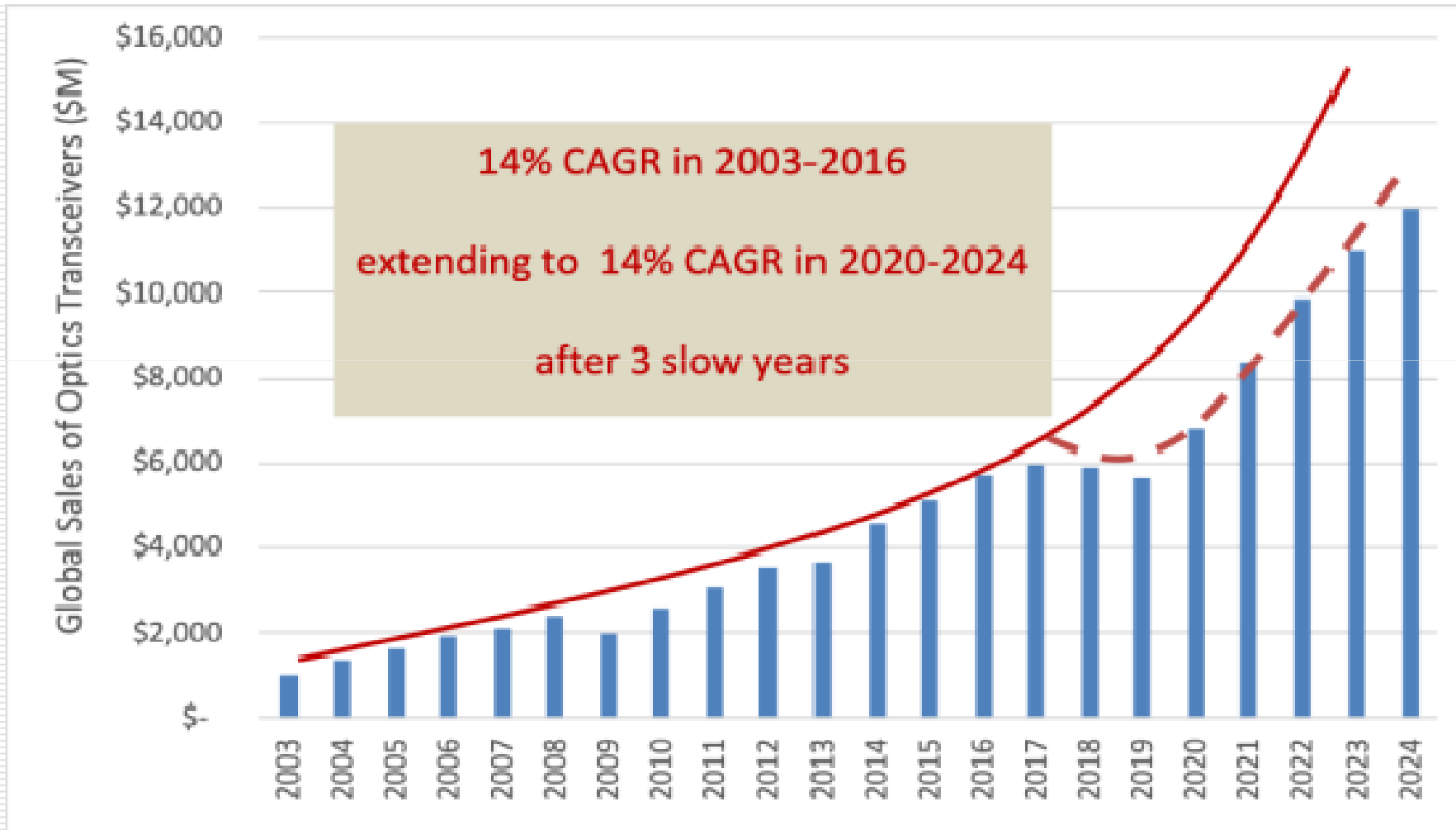
Laser Diodes & Direct Diode Lasers: Global Market Forecast



The market for laser diodes and direct-diode lasers will grow to \$13.985bn by 2029, comprising \$11.952bn for laser diodes and \$2.033bn for direct-diode lasers, according to the report 'Laser Diodes & Direct Diode Lasers 2019-2029' by market research and technology consulting firm IDTechEx of Cambridge, UK.



Optics Transceivers





VCSEL Application

High Power

**940nm 3D
Sensing/
808nm hair
removal and
other aesthetics
applications/
LiDAR for
Autonomous
Driving/
Surveillance**

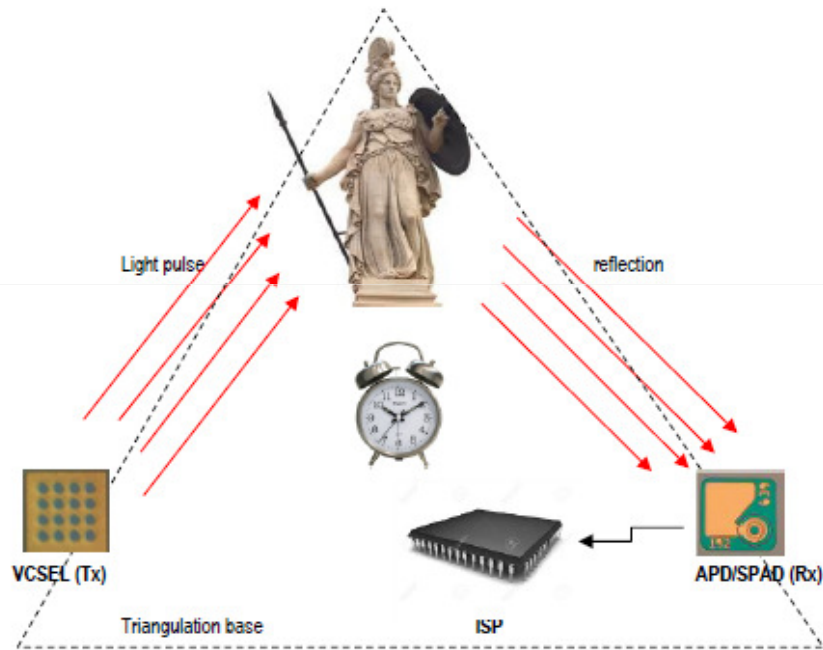
High Speed

**850nm
Datacom**



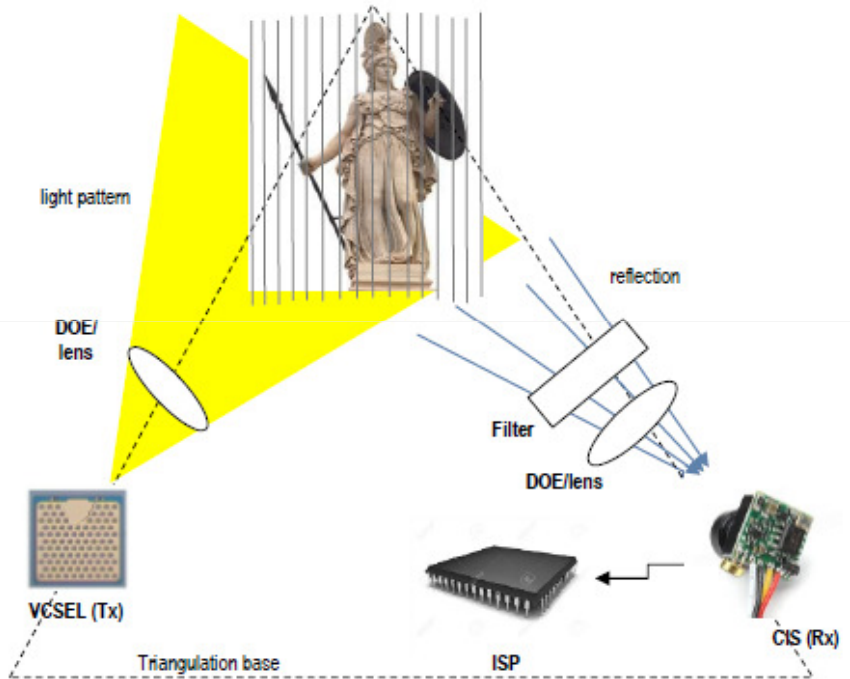
How does a 3D laser sensor work?

Time of flight



VCSEL spec		Product application
Dimension (mil)*	8-13	Proximity sensor, gesture recognition, AirBar,
# emission	2-20	laser-assisted autofocus, biometric recognition,
Power (mW)**	10-100	high-speed data transmission interface

Structured light



VCSEL spec		Product application
Dimension (mil)*	23-40	3D sensing/depth camera, AR/VR, night vision,
# emission	50-200	laser-assisted autofocus, laser lighting, medical device,
Power (mW)**	100-990	cobot, other IoT devices

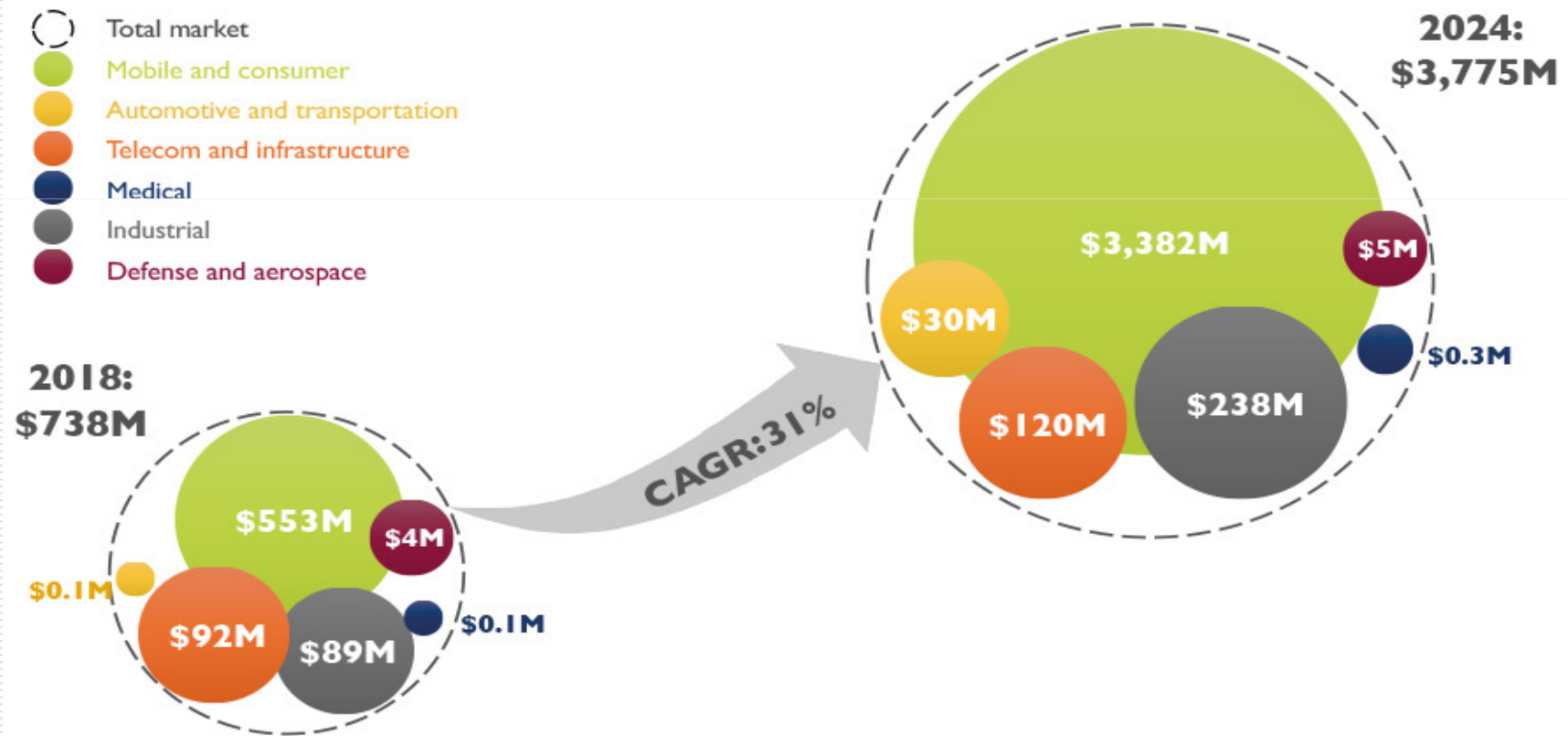
Source: Daiwa



VCSEL

2018-2024 VCSEL market revenue

(Source: VCSELS - Market and Technology Trends 2019, Yole Développement, May 2019)





ToF Adoption (2017- 2020)

图表 18: TOF 出货量测算

		2017	2018	2019E	2020E
苹果手机出货量	百万台	232.1	223.7	180	200
苹果 TOF 渗透率	%	0.0%	0.0%	0.0%	25.0%
苹果 TOF 出货量	百万台	0	0	0	50
三星手机出货量	百万台	317.3	293.6	300	310
三星 TOF 渗透率	%	0.0%	0.0%	10.0%	15.0%
三星 TOF 出货量	百万台	0	0	30	46.5
HMOV 等其他手机手机出货量	百万台	936.1	916.2	951.3	1000
TOF 渗透率	%	0.00%	1.00%	5.00%	11.00%
TOF 出货量	百万台	0	9.2	47.6	110.0
全球手机出货量	百万台	1485.5	1433.5	1431.3	1510.0
TOF 出货量合计	百万台	0.0	9.2	77.6	206.5
YoY 增长率	%			747%	166%

资料来源: IDC、国盛证券研究所预测



ToF Adoption in 2020

Figure 1: 2020 TOF 3D sensing shipments forecast by smartphone models units: mn

Launch	Models	Technology	Shipments
1Q20	P40	TOF	18
1Q20	P40+	TOF	8
4Q20	HonorV40	TOF	6
2Q20	HonorV30	TOF	14
4Q20	Mate40	TOF	10
4Q20	Mate40 pro	TOF	5
4Q19	Mate30 pro	TOF	5
1Q20	S11	TOF	20
1Q20	S11+	TOF	10
3Q20	Note11	TOF	10
3Q20	Note11+	TOF	5
3Q19	Note10+	TOF	5
3Q20	Samsung A80s	TOF	10
3Q19	Samsung A80	TOF	5
2Q20	OPPO	TOF	5
2Q20	VIVO	TOF	5
1Q20	Xiaomi Mi10 pro	TOF	6
2Q20	Lenovo Z7 Pro	TOF	3
1Q20	LG G9	TOF	5
3Q20	iPhone12	TOF	55
2Q20	total	TOF	210

Source: Yole, TrendForce, Fubon Research



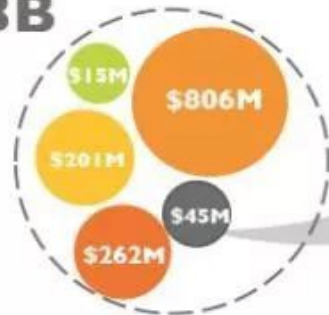
LiDAR Market Size

2018-2024 LiDAR market forecast by application

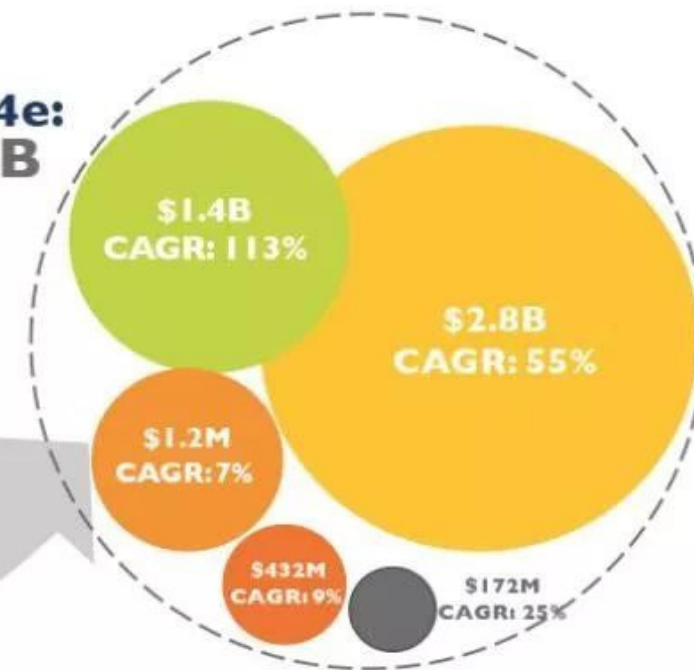
(Source: LiDAR for Automotive and Industrial Applications 2019, Yole Développement, March 2019)

- Total market
- Robotic vehicles
- ADAS vehicles
- Topography
- Wind
- Industry

2018:
\$1.3B



2024e:
\$6B



CAGR:
29%

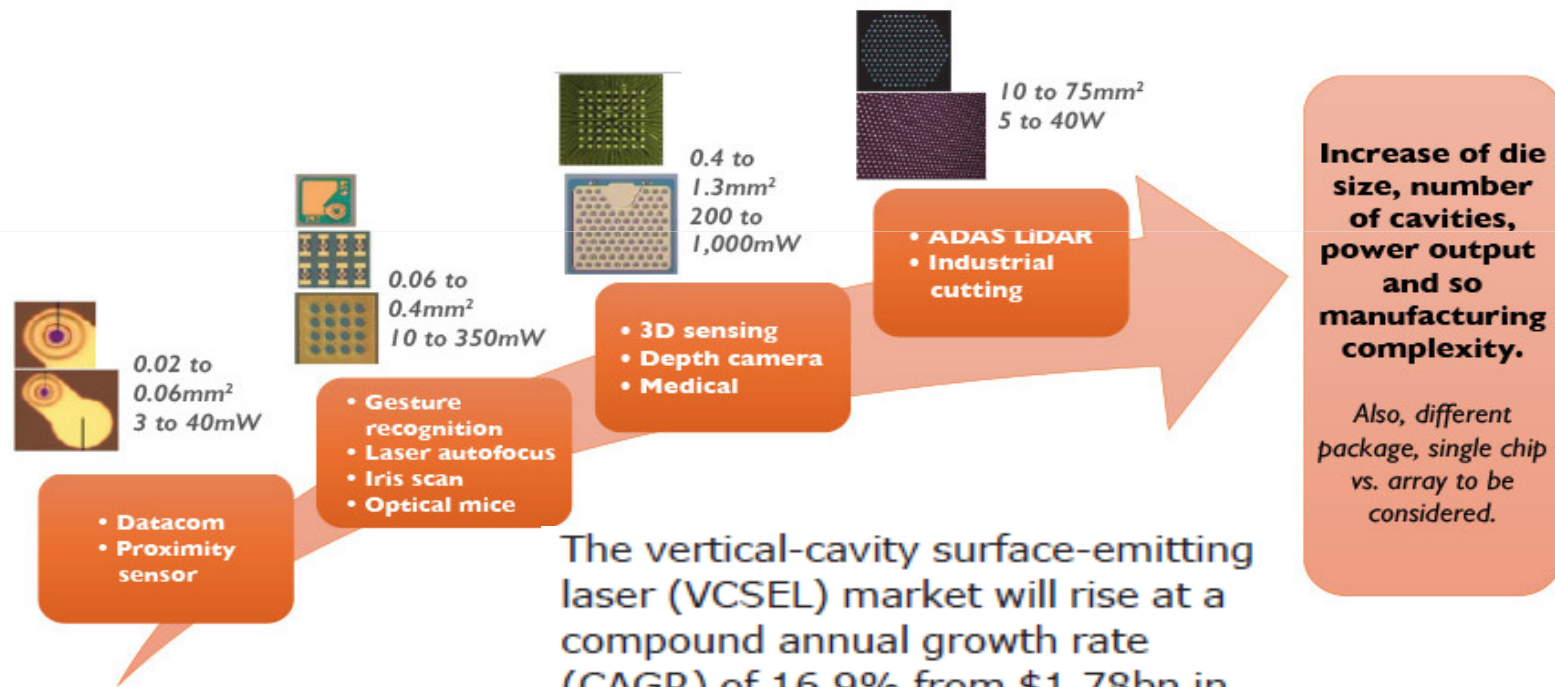
MEMS



VCSEL

VCSEL specifications vs. Application requirements

(Source: VCSELS - Technology, industry and market trends, Yole Développement, July 2018)

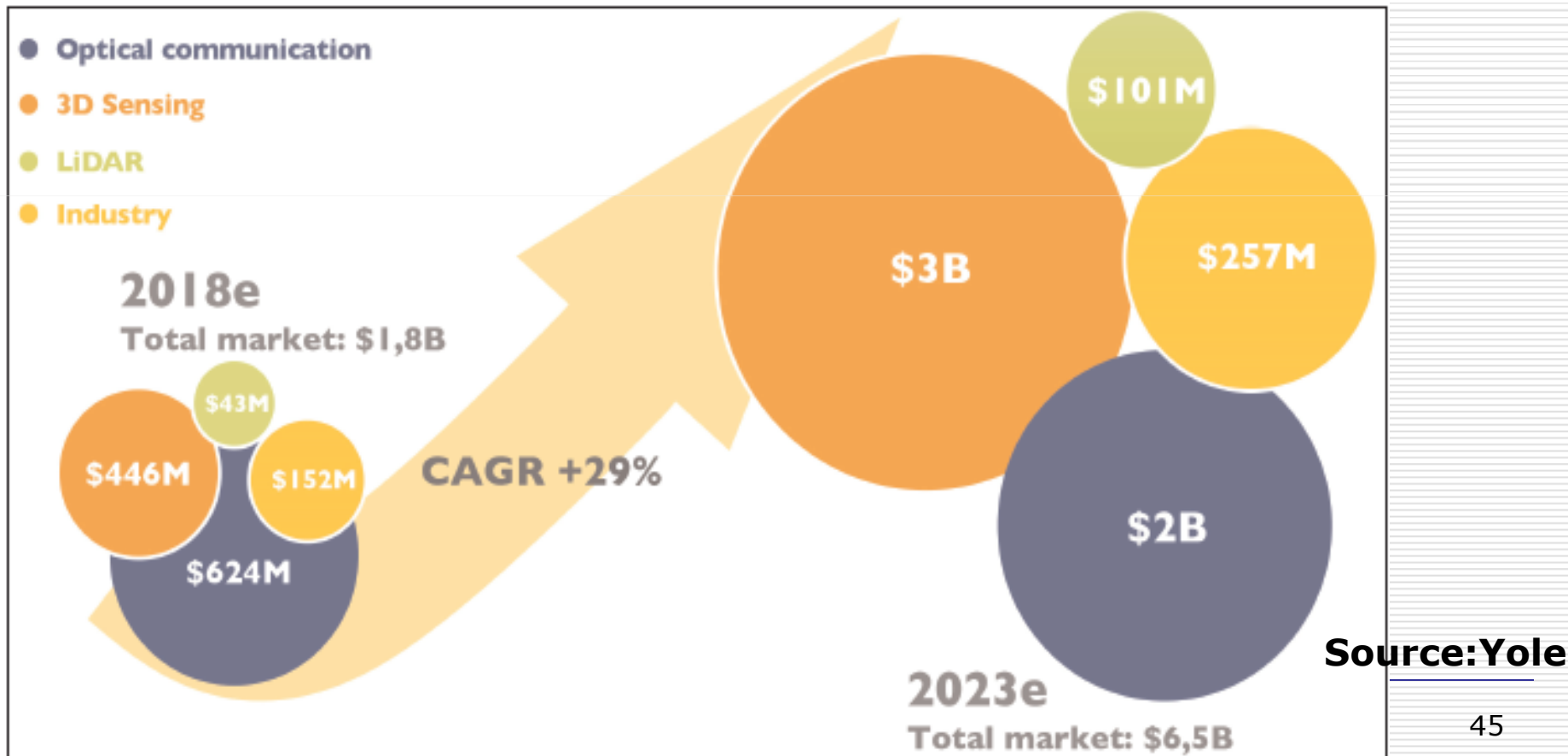


The vertical-cavity surface-emitting laser (VCSEL) market will rise at a compound annual growth rate (CAGR) of 16.9% from \$1.78bn in 2018 to \$3.89bn by 2023, according to a report 'VCSEL Market Report 2018 — Global Forecast to 2023' by the firm Markets and Markets.



Infrared(IR) Market Size

The infrared (IR) light source market will rise at a compound annual growth rate (CAGR) of 29% from \$1.8bn in 2018 to \$6.5bn in 2023, forecasts Yole Développement in 'IR LEDs & Laser Diodes — Technology, Applications, And Industry Trends report'.



Infrared light source market forecast — by key segment.



PIN Diode

收光晶粒之上游材料,可用於PIN & APD
具元件驗證能力
技術能力已達25G

Image sensor's application: The concept of "Machine Vision"

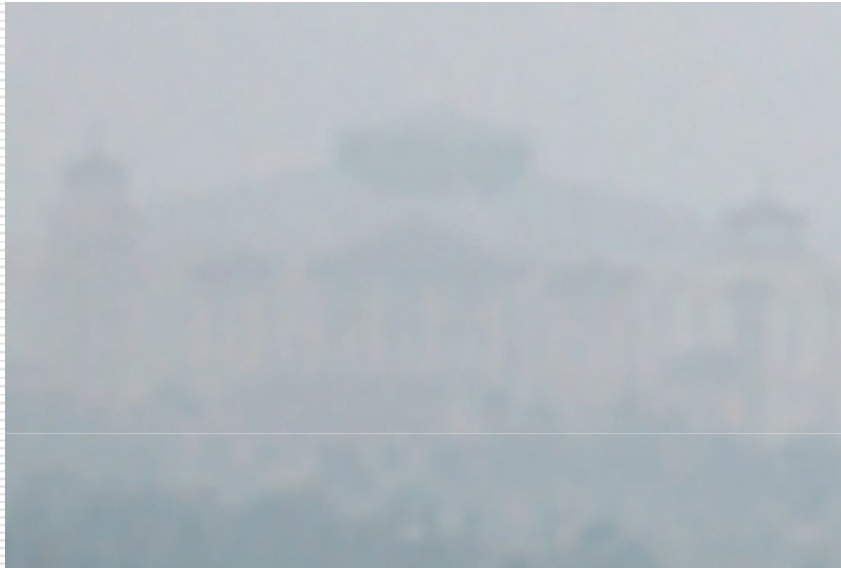


Seeing in Low Light Conditions- Night Vision





Penetrate Atmosphere Obscurants



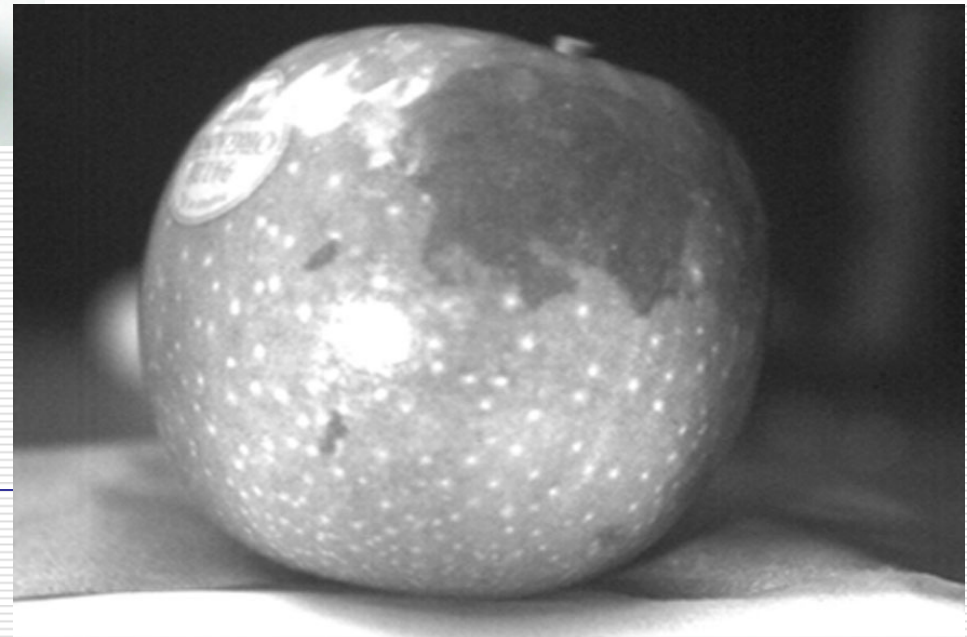


Seeing through Smoke and Fire



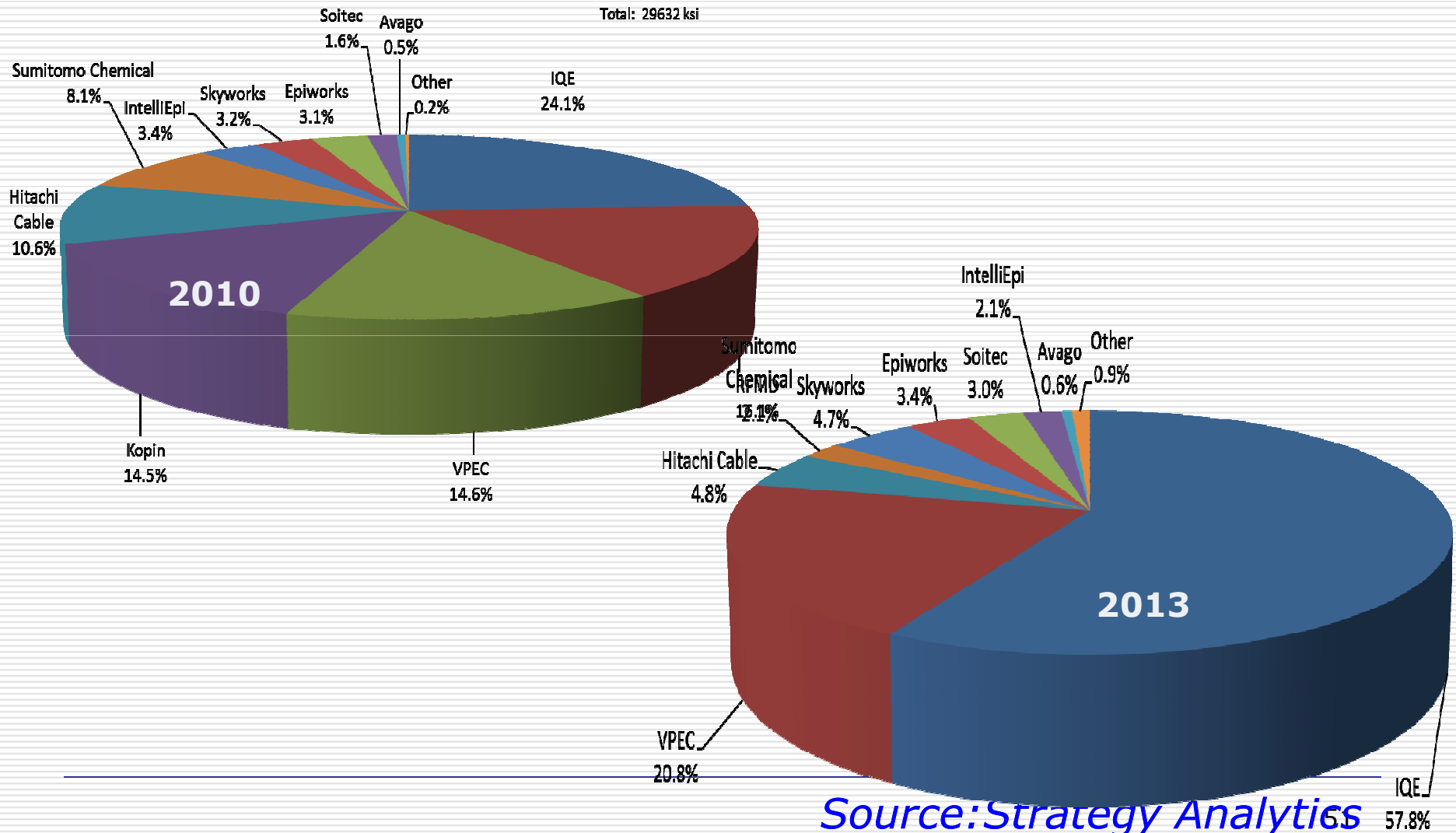


Product Inspection



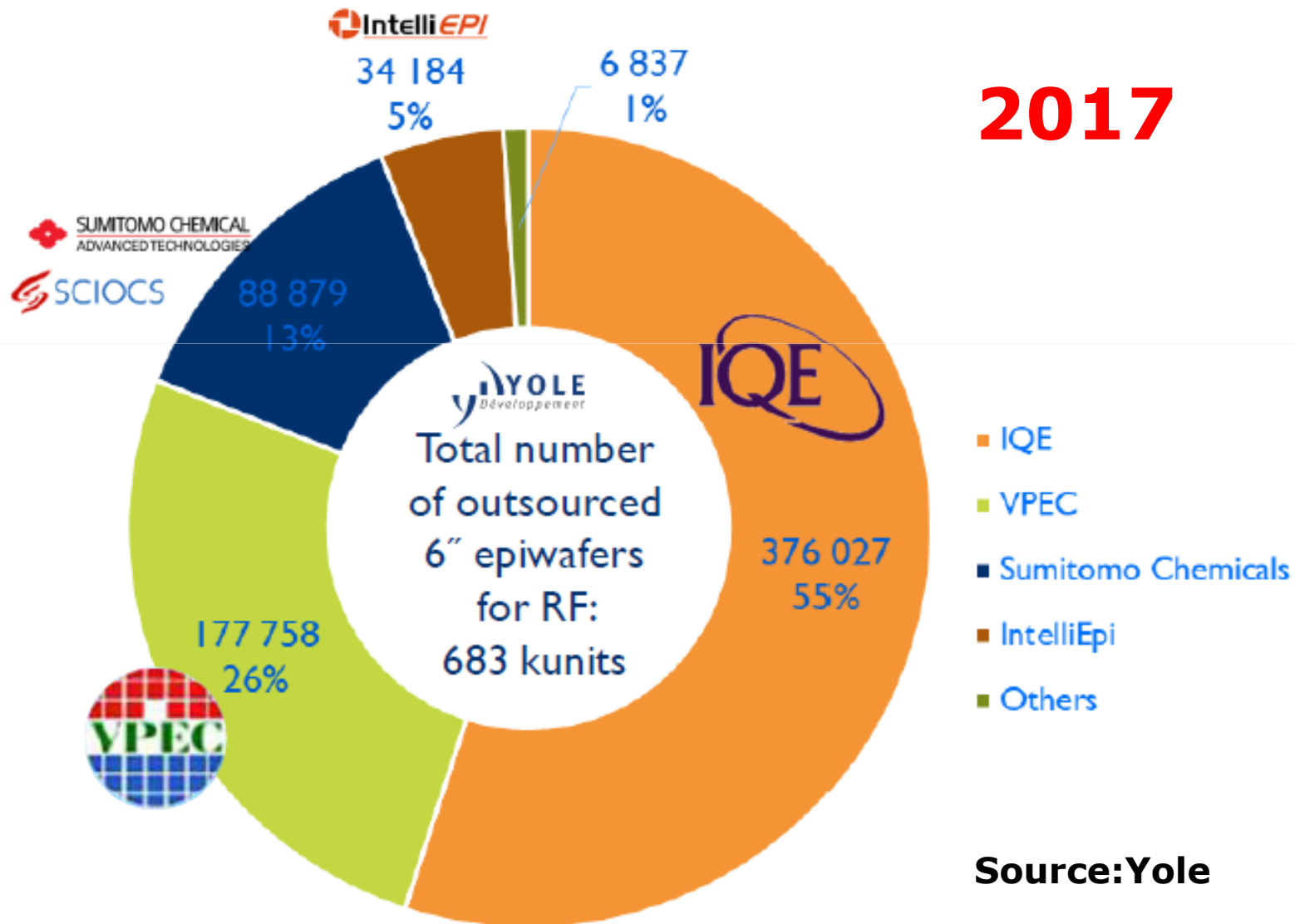


Epi Wafer Market Consolidation





ESTIMATED GaAs RF EPIWAFER SHARES (OPEN MARKET)





2016-2019 Q3 Financial Result

	2019 Q1 ~ Q3	%	2018	%	2017	%	2016	%
Revenue	1,787,611	100.00%	2,062,120	100.00%	2,137,109	100.00%	2,182,825	100.00%
Gross margin	746,369	41.75%	774,359	37.55%	743,467	34.79%	809,059	37.06%
Operating Profit	462,985	25.90%	463,906	22.50%	515,093	24.10%	588,072	26.94%
Financial Income	7,320	0.41%	25,273	1.23%	-35,375	-1.66%	-29,431	-1.35%
Tax	-82,318	-4.60%	-92,009	-4.46%	-85,366	-3.99%	-91,534	-4.19%
Net income	387,987	21.70%	397,170	19.26%	394,352	18.45%	467,107	21.40%
EPS	2.11		2.16		2.15		2.12	



2020 Outlook

- New Momentum
 - ✓ 5G smartphone/IOT Application(802.11ac or 802.11ax(WiFi 6))
 - ✓ ToF adoption
- Healthy Portfolio
 - ✓ By products(improve product mix & margin)
 - ✓ By customers