Soitec’s engineered substrates for 5G

March 2020

Outline

1 **What is 5G about?**

2 5G will drive semiconductor content growth

3 Soitec’s engineered substrates to enable 5G

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5G technology in numbers

100x
Network capacity
(*)

10x
Speed
(*)

10x
Fastest response time
(*)

10x
Connected device
(*)

(*) Source: Qualcomm

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5G world – beyond smartphones

5G for automotive

Key services

- Autonomous driving
- Infotainment
- Telematics

5G for IoT

Key services

- Smart everything: home, city, offices, energy
- Security
- Healthcare

5G for manufacturing

Key services

- Higher automation
- Higher productivity
- Higher quality, higher security…

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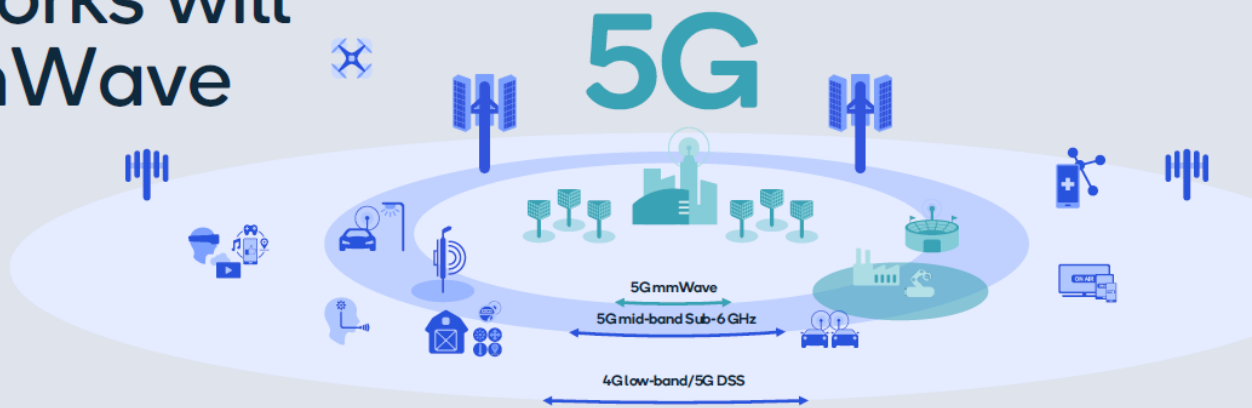
5G – a combination of networks

Leading 5G networks will have Sub-6 + mmWave

Combining coverage, capacity, and performance benefits



Source: Qualcomm Analyst Day, C. Amon, Nov. 2019

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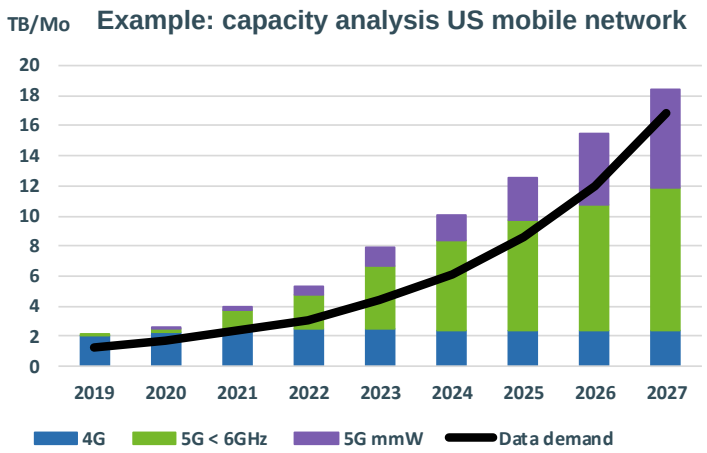
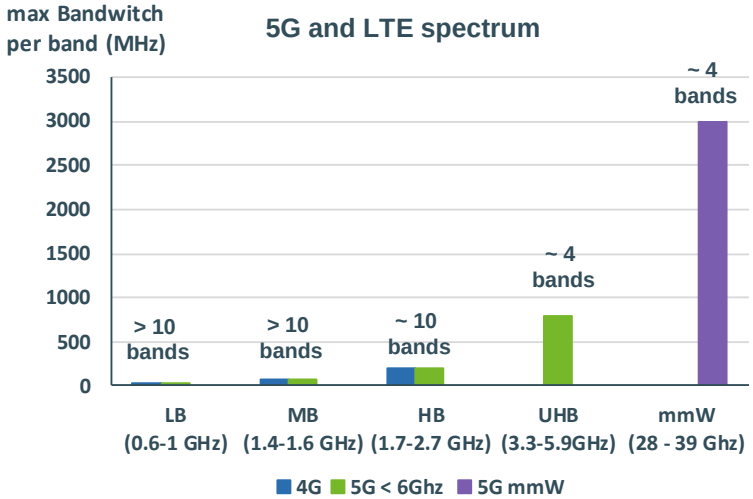
5G – a larger frequency spectrum to manage more data faster

- 5G new spectrum is 12x larger than overall LTE
- Will enable network providers to deliver increasing data rate for the next 10 years





Source: Mobile Experts, Soitec estimates, 2019

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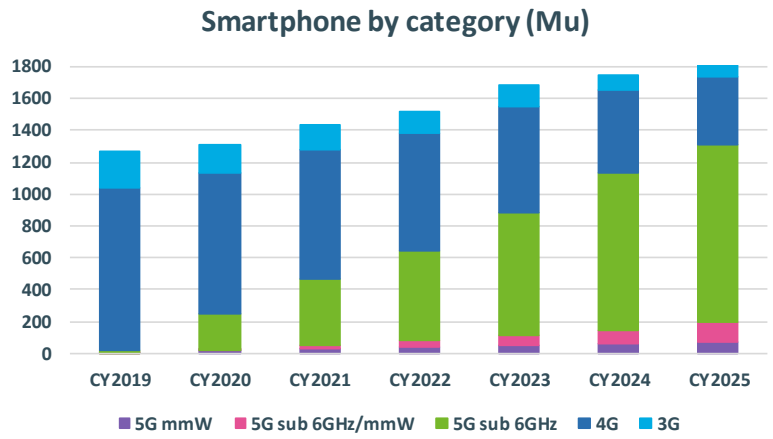
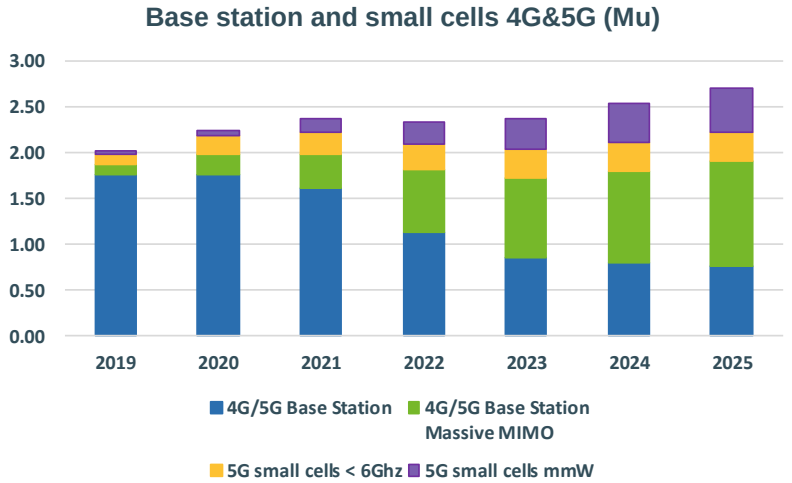
5G massive deployment is starting in 2020

› **50% of smartphones sales in 2023**
  › around 200Mu in 2020



Source: Navian October 2019, Soitec estimates beyond 2023

› **110 5G Operators (Ookla daily update)**
  › around 200k 5G base stations in 2020
  › >55% of worldwide coverage in 2025



Source: Yole, November 2019

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5G roadmap will drive technology and applications for the next decade

Source: Qualcomm Analyst Day, J. THOMPSON, Nov. 2019

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Front End Module (FEM) blocks – built on Soitec substrates

- **Switch**

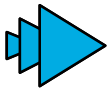
  Antenna switch
  Power mode switch, …

- Swapping switch

- **Low noise amplifier (LNA)**

- **Supply modulator**
  ET: enveloppe tracker type of S

- **Power amplifier (PA)**



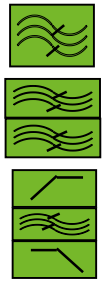
- **Antenna tuner**

- **Filters**

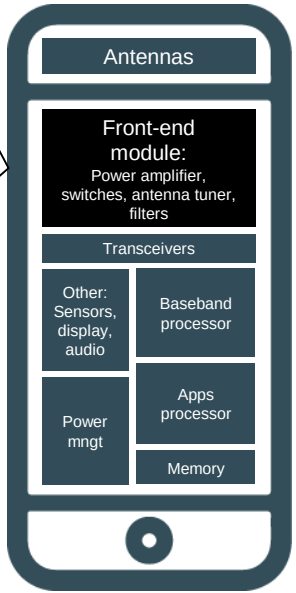
  Bandpass filter

  Duplexer(s)

  Antennaplexer



- **Phase shifter(s)**



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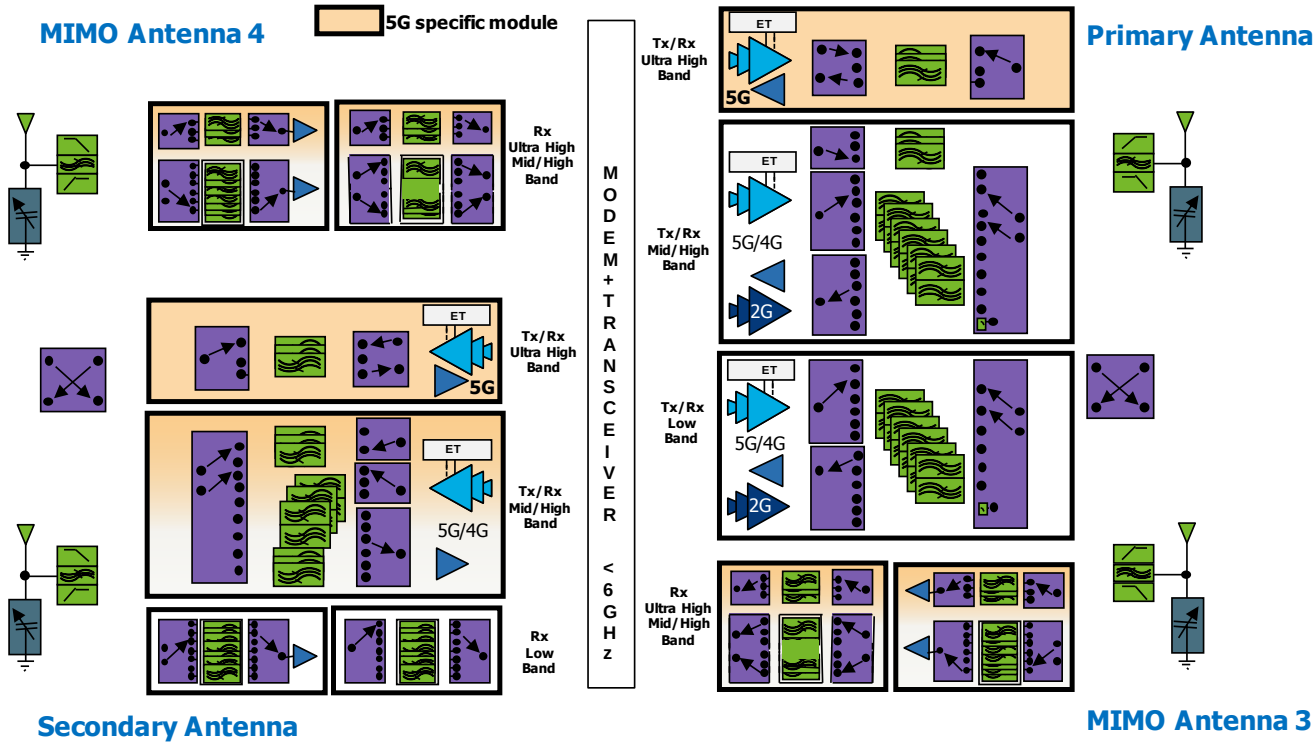
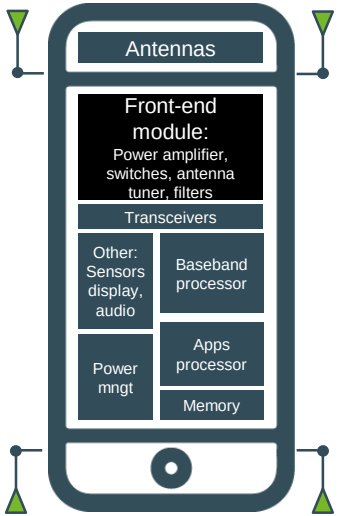
5G sub-6GHz – High end* smartphones: 20% more RF FEM content vs 4G





*: >$500
30% of smartphones

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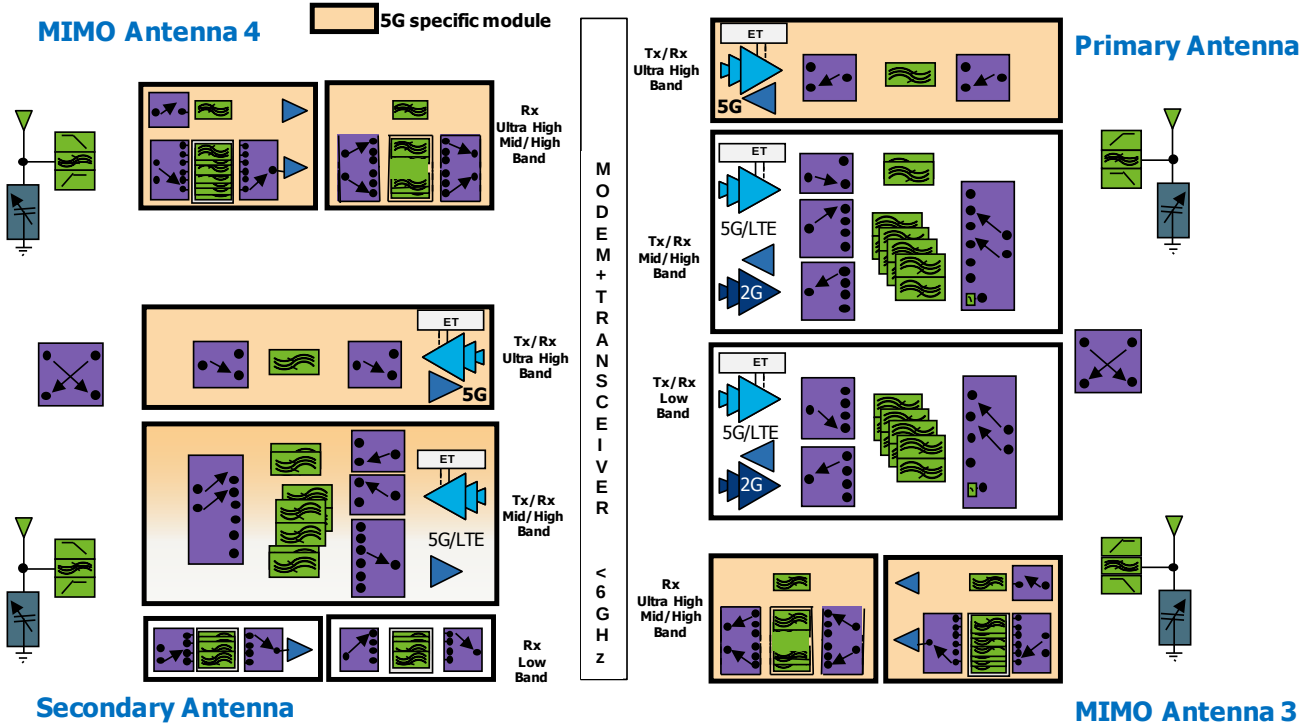
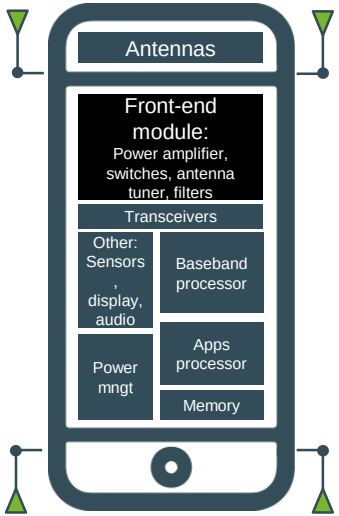
5G sub-6GHz – Mid end* smartphones: 90% more RF FEM content vs 4G





*: $100 - $500
50% of smartphones

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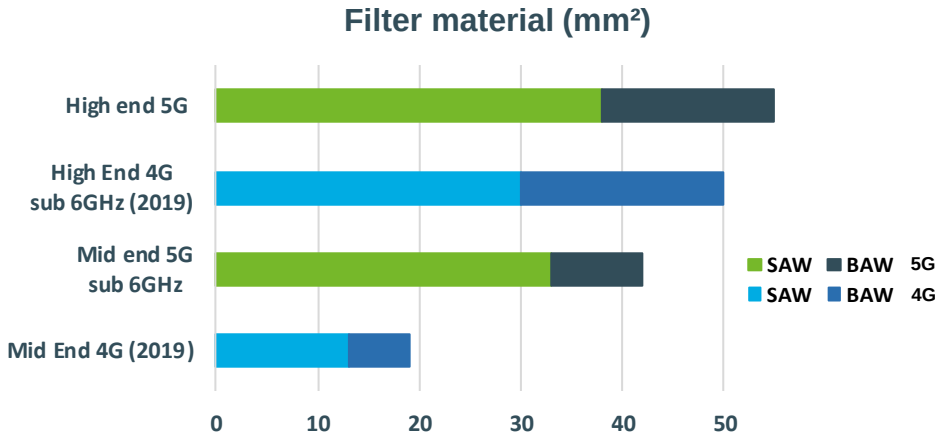
5G sub-6GHz
Major content (*) growth for RF-SOI and filters

Average +60% RF-SOI content

Source: System Plus 2019, Soitec estimates

Average +50% filter content



Assumption: new SAW filter generations to take market share over BAW

(*) Mm² are serviceable accessible market

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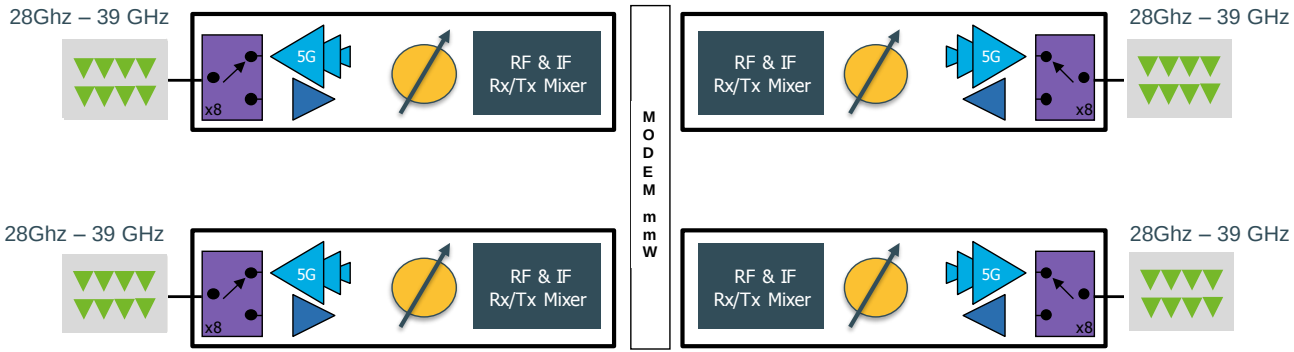
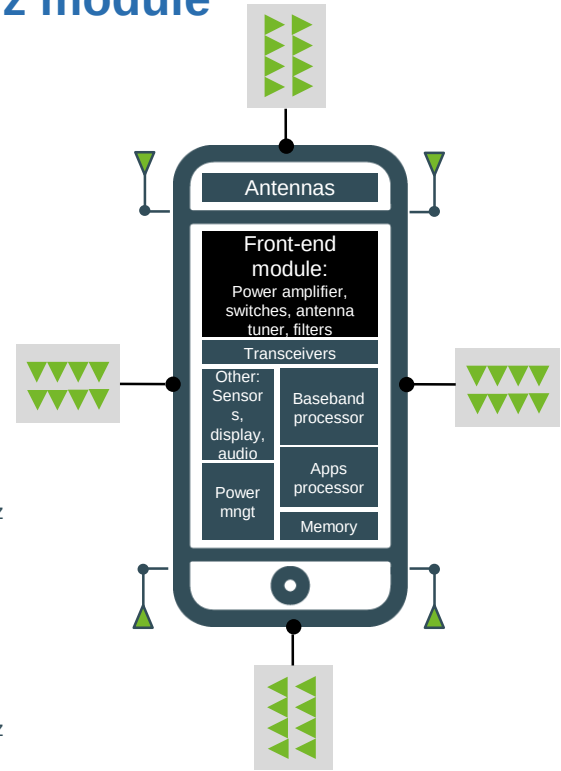
5G mmW module brings additional content to sub-6GHz module

- **5G mmW requires 3 or 4 modules**
  - Modules are required so that mmW signal is not blocked by hand nor objects
  - Modules are put on the phone edge

- **28Ghz and/or 39GHz bands**
  - Starts with one band and will move to two bands





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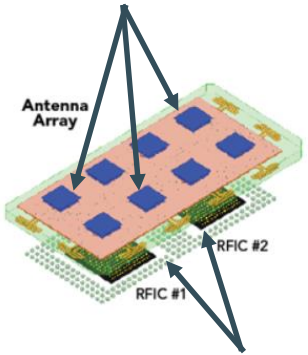
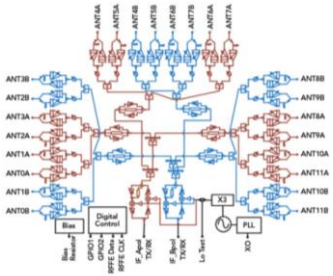
5G mmW smartphone
Doubling SOI (*) content vs 5G sub-6GHz smartphone

5G mmW handset modules – in average: 60 mm² of RF-SOI or FD-SOI

8 antennas per module

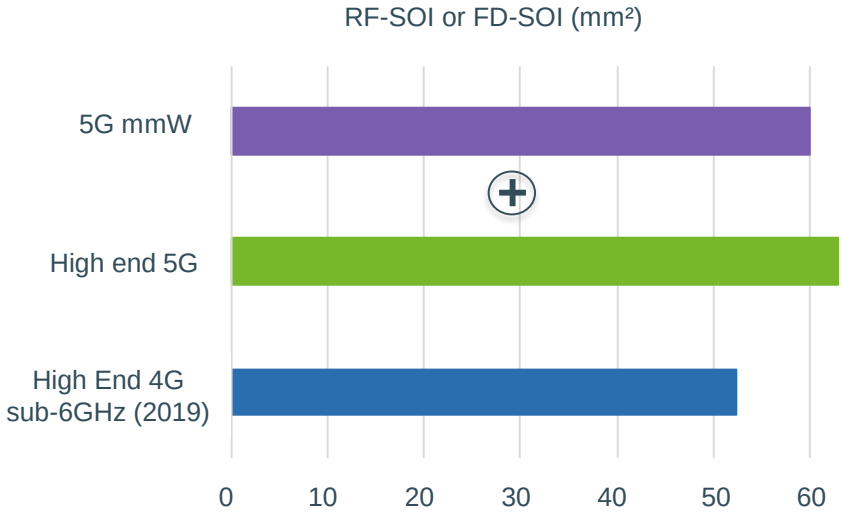


2 transceivers
per module, 10mm² each



Transceivers :
PA, LNA, SW,
PLL, Digital
control

Source: Qualcomm IMS 2018, Microwave Journal Dec 2018



Source: Soitec estimates

(*): Mm² are serviceable accessible market

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Soitec technologies in 3G, 4G, 5G products
From alternative solution for RF switch to standard RF FEM

SOI Antenna Switch
(Wi-Fi first introduction)

iPhone 4S

iPhone 5

Galaxy S5

iPhone 8

Mate Pro 30

Galaxy S20 Mate 20 X

	2G	3G	LTE	LTE-A	LTE-A-Pro	5G sub-6GHz	5G (sub-6GHz + mmW)	
RF-SOI	**1**	**2**	**7**	**20**	**40**	**50**	**65**	**mm²**
FD-SOI (*)						**2 ➡ 65**		**mm²**
POI						**2 ➡ >25**	**>25**	**mm²**

Source: System Plus, Soitec estimates

⇨ next generations (*) either FD-SOI or RF-SOI Mm² are serviceable accessible market

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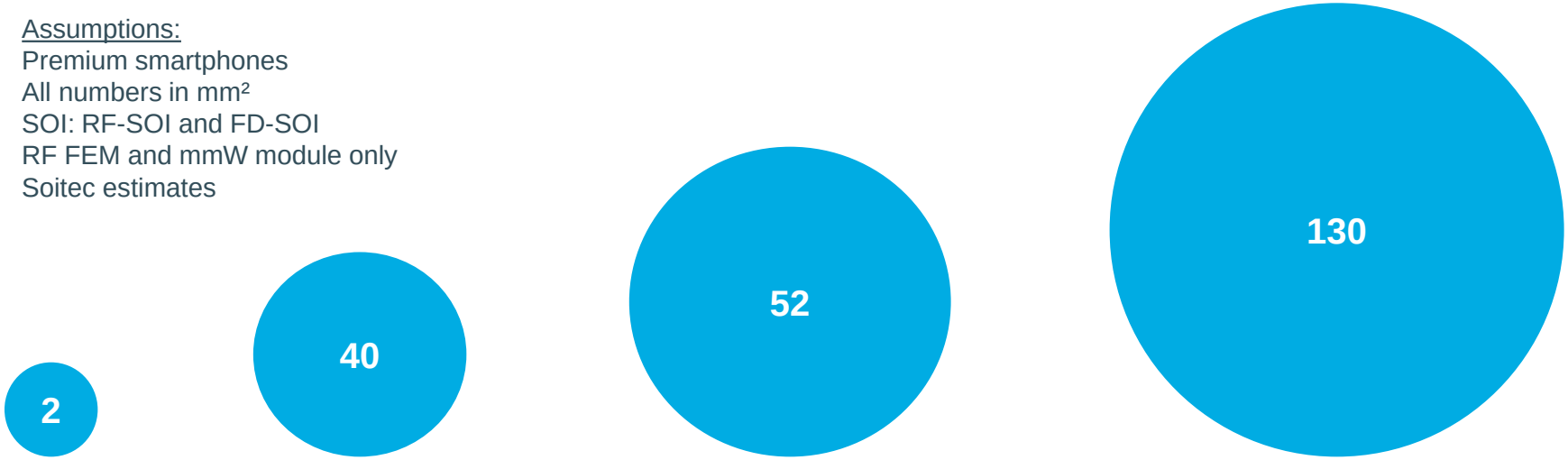
Soitec “footprint” in mm² across RF standards

Assumptions:
Premium smartphones
All numbers in mm²
SOI: RF-SOI and FD-SOI
RF FEM and mmW module only
Soitec estimates



Mm² are serviceable accessible market

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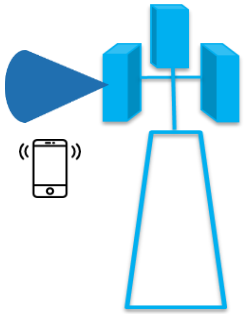
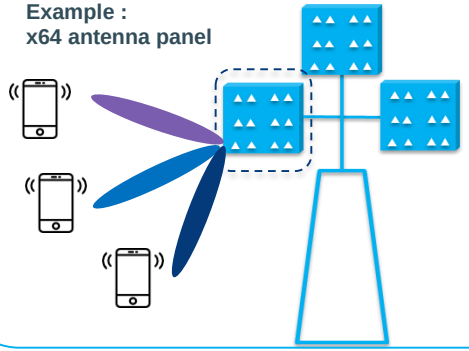
5G sub-6GHz base station architecture: major change



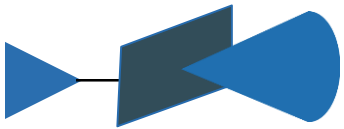
› **4G/5G base station**
- › Passive antenna system
- › One antenna per panel

Example :
x64 antenna panel

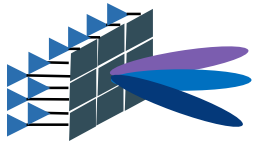


› **5G massive MIMO**
- › Active antenna system
- › Cell coverage improved
- › More user served simultaneously

x1



x 64



/ 64 › Power per PA

x 64 › FEM (units)

Key challenges require from semiconductor suppliers

› PA performance stretching above 3.6GHz
- › High power added efficiency

› Low cost FEM solution

› Low-power solution

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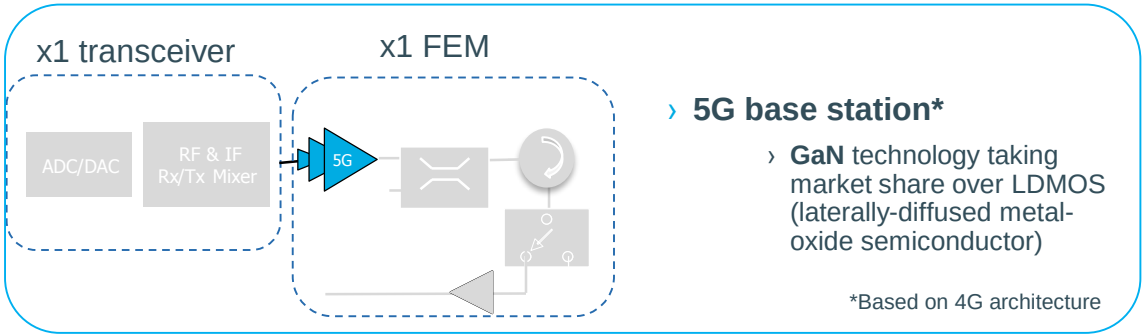
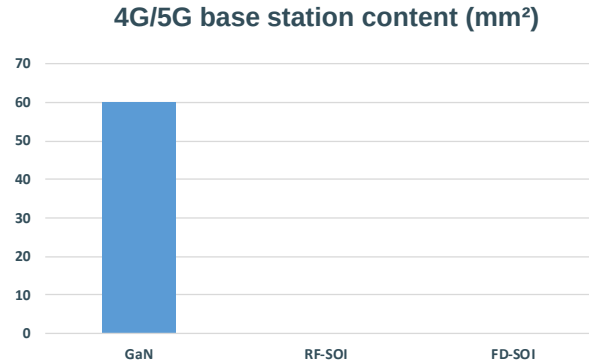
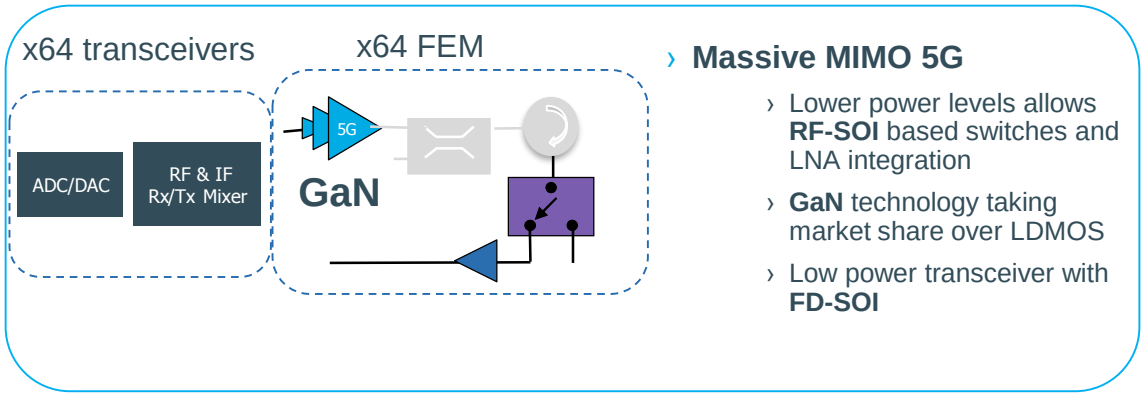
5G sub-6GHz base station: new opportunities for Soitec



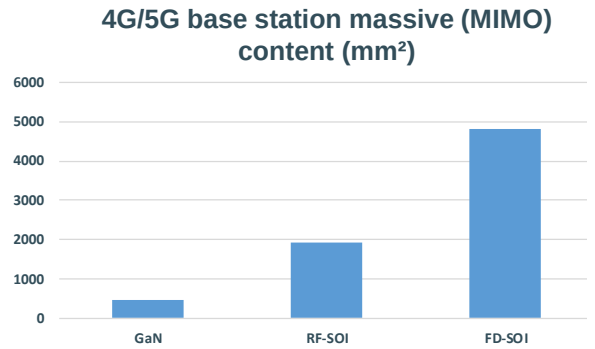
- **5G base station***
  - **GaN** technology taking market share over LDMOS (laterally-diffused metal-oxide semiconductor)

*Based on 4G architecture





- **Massive MIMO 5G**
  - Lower power levels allows **RF-SOI** based switches and LNA integration
  - **GaN** technology taking market share over LDMOS
  - Low power transceiver with **FD-SOI**



Remark: handset unit is 1,000 larger than base station

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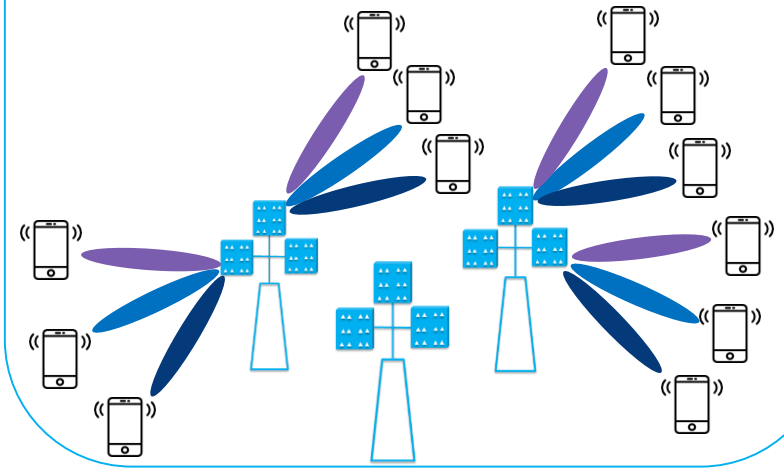
5G mmW small cells: new end-to-end architecture

5G mmW small cells

- Ultra high bandwidth
- Ultra high throughput
- Increased semiconductor content (until 1024 RF chains)
- 28-39GHz bands

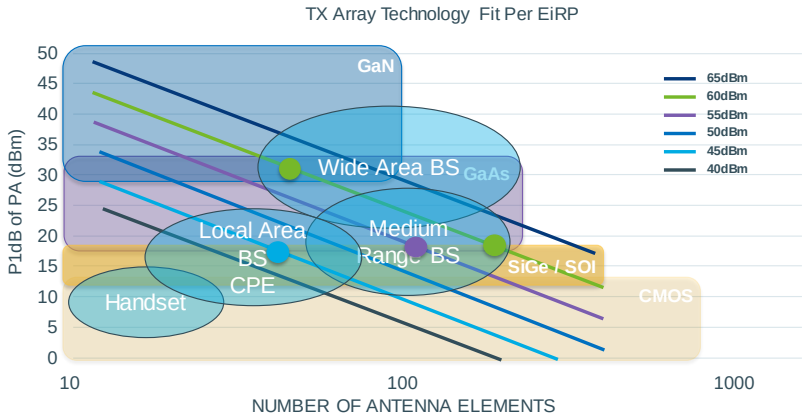


Multiple type of small cells per market segment

- Wide, medium, local area coverage

GaN and SOI cover all cases (ex: wide area small cells)

- x64 antennas with high power GaN PA
- x512 antennas with SOI integrated FEM



Source: Analog Devices, 2019

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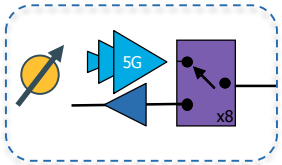
5G small cells mmW: new opportunities for Soitec

X16 chipsets transceivers

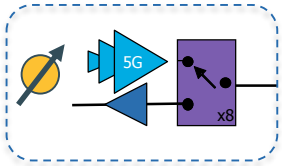
x64 FEM



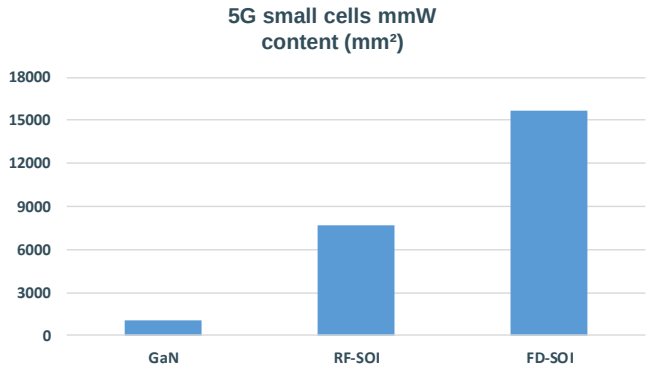
› **Low complexity approach**
  › FEM in **GaN**
  › Low power transceiver with **FD-SOI**

X128 chipsets transceivers

x512 FEM



› **High complexity approach**
  › FEM in **RF-SOI or FD-SOI**
  › Low power transceiver with **FD-SOI**



Remark: handset unit is 3,000 larger than small cells

Remark: either GaN or RF-SOI or FD-SOI will be chosen for mmW FEM

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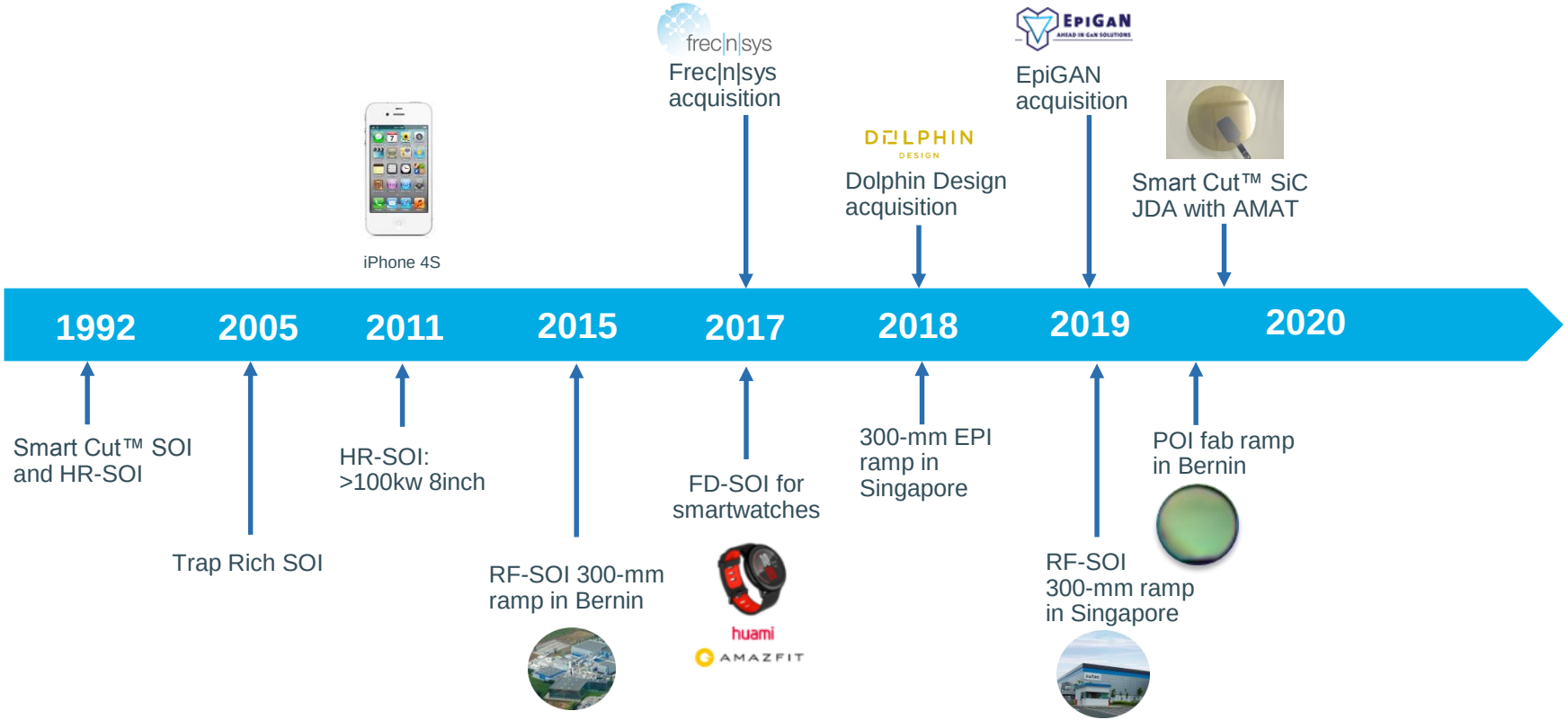
Soitec key milestones in serving the RF market



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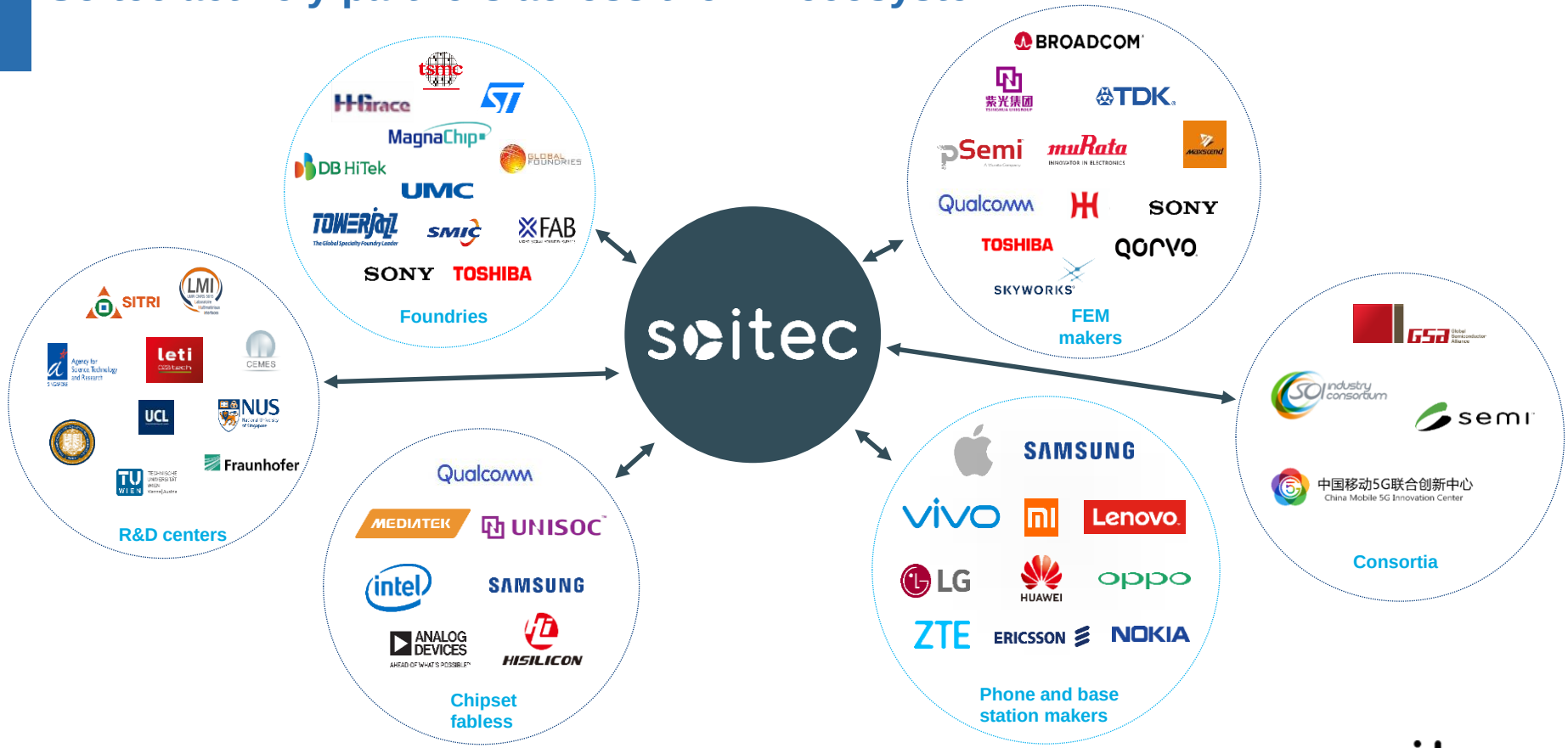
Soitec actively partners across the RF ecosystem



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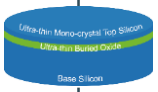
A broad product portfolio of engineered substrates

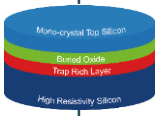
PROCESSOR & CONNECTIVITY SOC

FD-SOI
For power-efficient integration of digital/ analog/RF



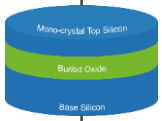
RF FRONT-END MODULE

RF-SOI
For highly efficient mobile communication



POWER

Power-SOI
For high voltage device integration

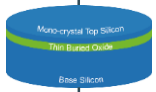


PHOTONICS

Photonics-SOI
For high perf. photonics device integration into silicon

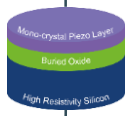
IMAGERS

Imager-SOI
For improved imager performance in NIR



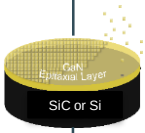
PIEZO-ON-INSULATOR

POI
For high performance 5G filters



GaN

GaN
For radio frequency (RF) 5G and power systems



SOI products

Piezo & compound products

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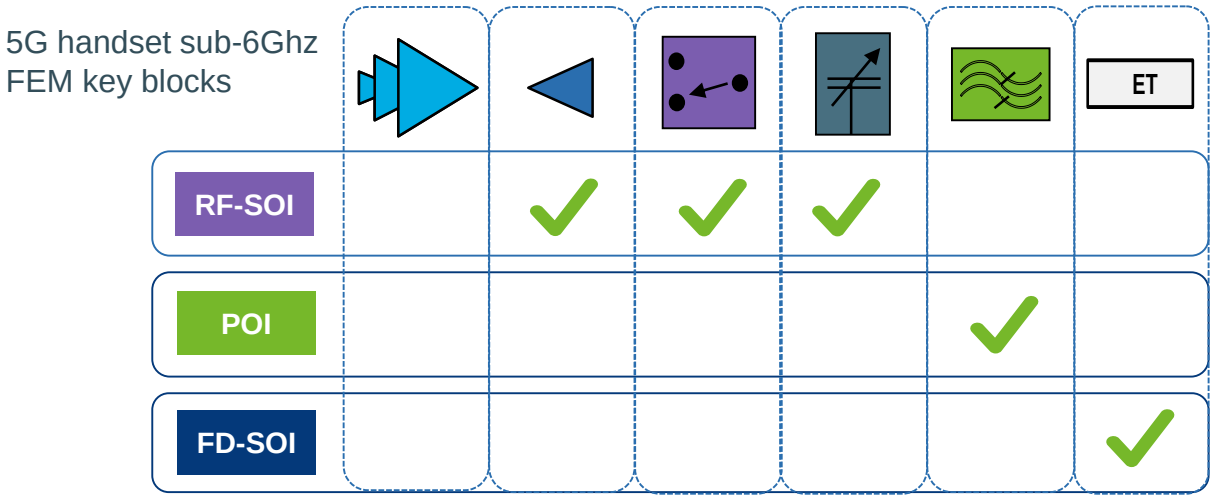
Soitec comprehensive product portfolio for 5G sub-6GHz handset RF FEM

- RF-SOI mainstream technology for switch, LNA, tuner
- POI target to become mainstream technology for filters



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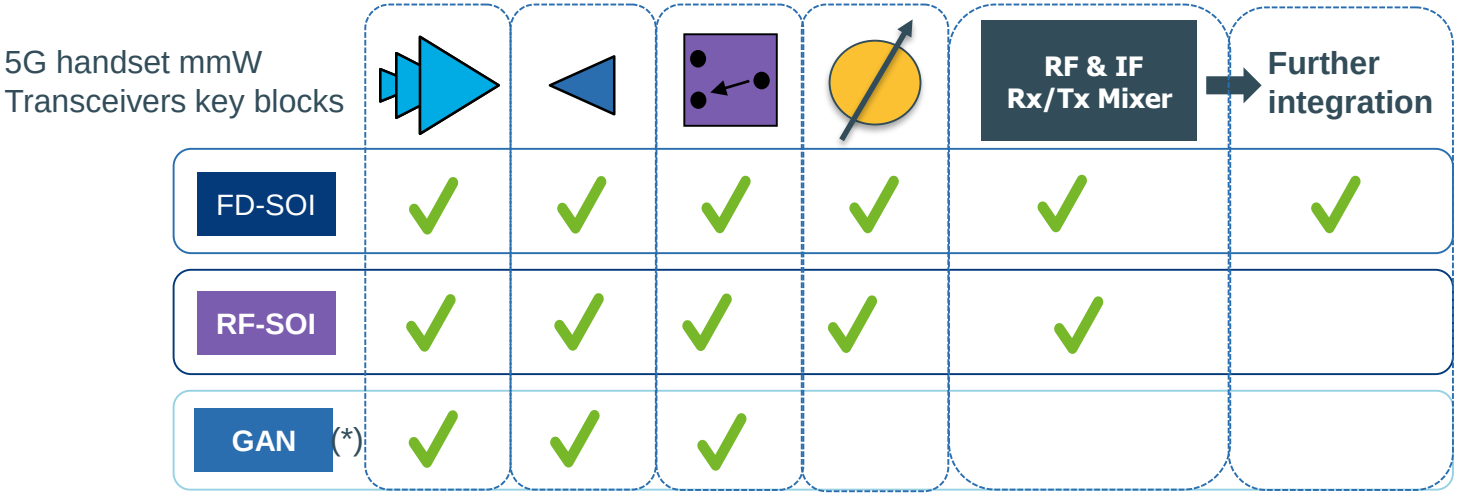
Soitec comprehensive product portfolio for 5G mmW handset RF FEM

- Addressing different integration options
- FD-SOI and RF-SOI (< 65 nm node) are both ideal technologies for mmW FEM
  - Enable full FEM integration on single die critical for mmW to avoid interconnect losses
  - Chipset leaders favor FD-SOI while FEM leaders favor RF-SOI
- GaN delivers high performance for PA



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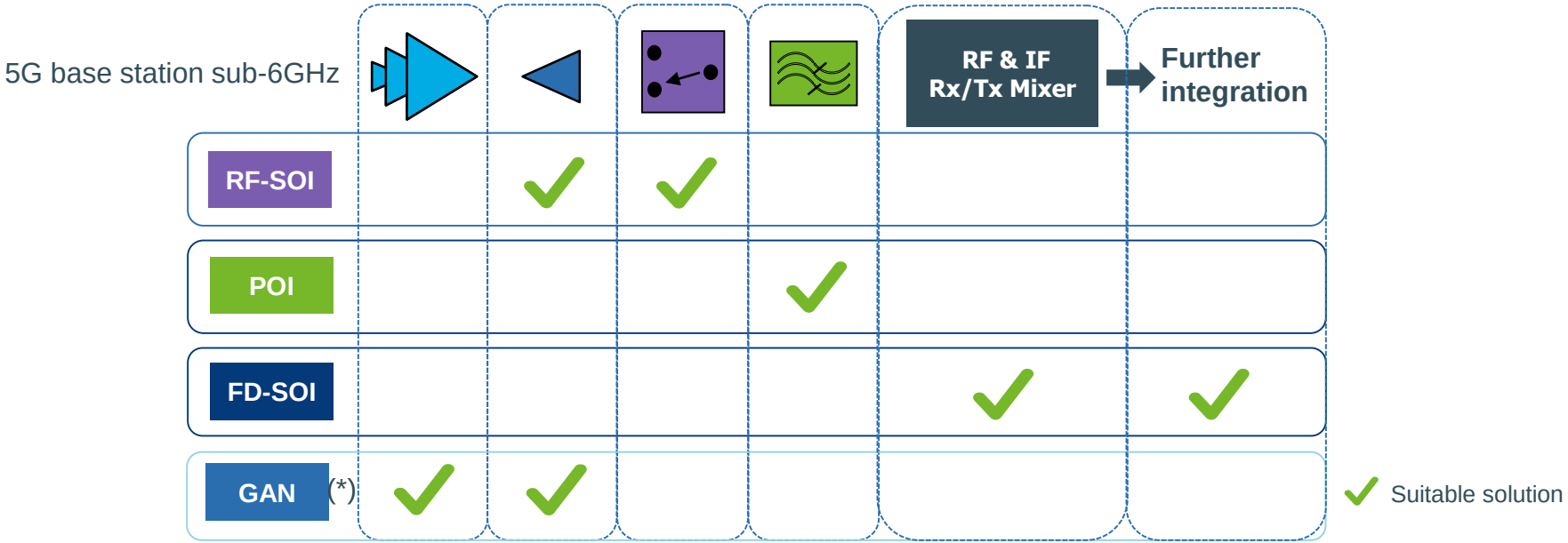
Soitec comprehensive product portfolio for 5G sub-6GHz base stations

› Soitec's product portfolio addresses most 5G base stations sub-6Ghz blocks



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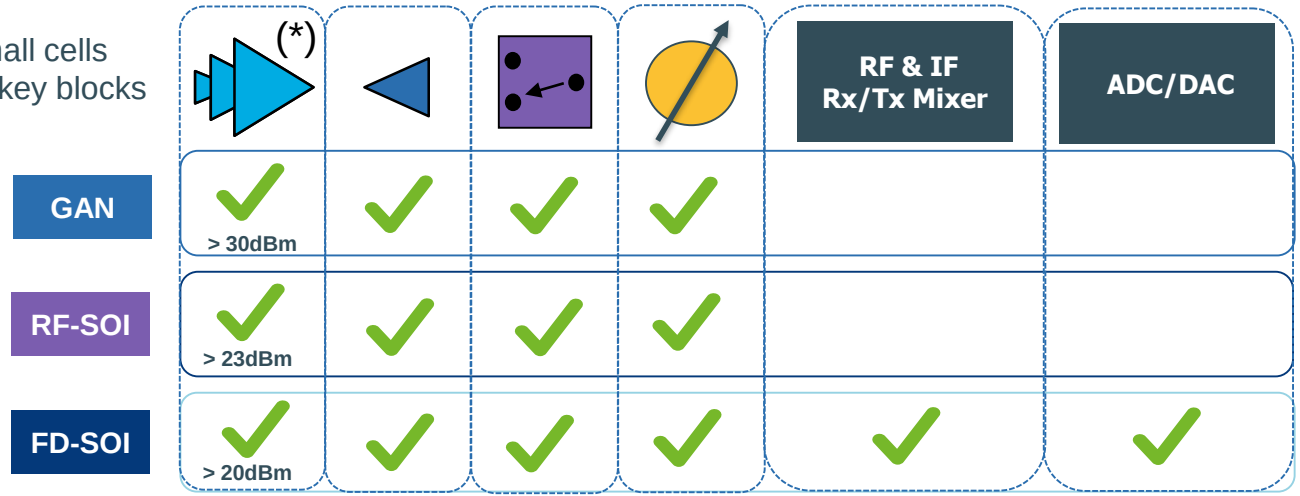
Soitec comprehensive product portfolio for 5G mmW small cells integration choices

- GaN is the solution low complexity antenna
- RF-SOI and FD-SOI are the solution for high complexity antenna

5G mmW small cells transceivers key blocks



(*) : >30dBm for < 16 antenna, >23dBm for 128 antenna, >20dBm for >256 antenna

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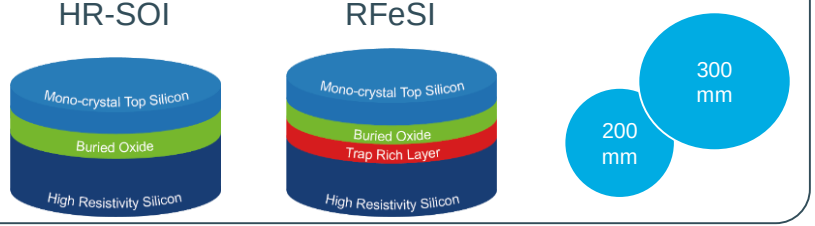
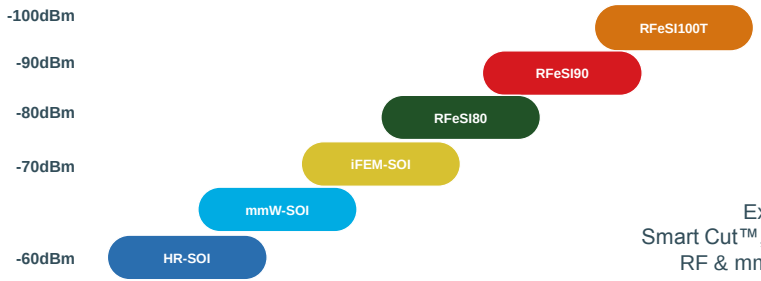
RF-SOI – standard for 4G and 5G RF FEM

Product description



A solid product roadmap



Expertise:
Smart Cut™, RFeSI,
RF & mmW FoM

Global platform for 5G FEM

	SOITEC RF-SOI	HR Silicon Bulk	Silicon Germanium	MEMS	GaAs
Switch	+	=	-	+	+
Tuner	+	-	-	+	+
Power Amplifier	=	-	=	n.a	+
Cost	+	+	=	-	=
Integration / Area	+	+	+	-	-
Volume manufacturing 200/300mm	+	=	=	-	-

\+ optimum = suitable - not suitable

Source: Soitec analysis

Soitec manufacturing

Bernin 1 200mm	Bernin 2 300mm	Pasir Ris 300mm	Simgui 200mm

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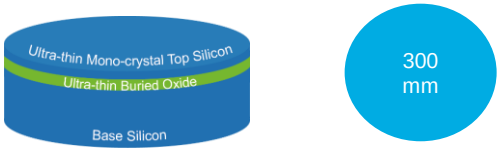
FD-SOI for 5G mmW and system-on-chip (SoC)

Product description



FD-SOI offering

node	55nm	28nm	22nm	18nm	12nm	≤10nm
Status	Prod	Prod	Prod	Pilot	Dev	R&D
eMemory	No	Yes	Yes	Yes	Dev	R&D
RF perf.	Yes	Yes	Yes	Yes	Dev	R&D

Expertise :
- Dolphin Design providing IP solution to fabless to master power management
- FD-SOI body biasing deployed as main pillar
- High resistive substrate applied to FD-SOI technology

Value proposition vs alternative technologies

	SOITEC FD-SOI	Planar bulk sub-40nm	Bulk FinFET sub-16nm	Silicon germanium
Best in class RF/mmW technology	+	=	=	+
System energy efficiency	+	=	+	=
Robustness (safety mission)	+	=	=	=
Cost	=	+	=	-
Integration SoC plateform	+	+	=	-

\+ optimum = suitable - not suitable

Source: Soitec analysis

Soitec manufacturing

Bernin 2
300mm

Pasir Ris
300mm

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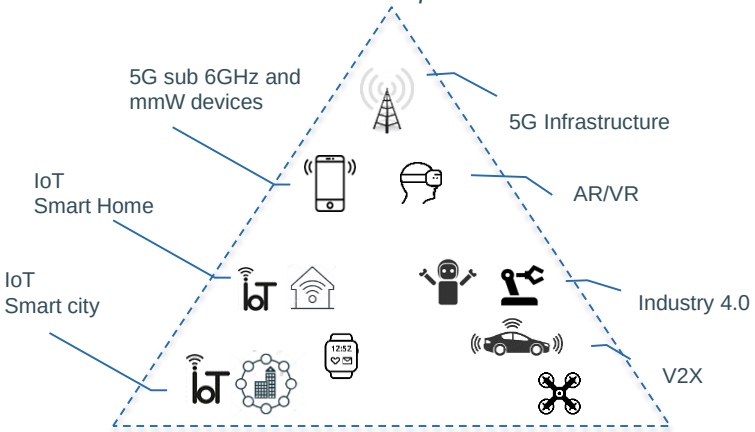
FD-SOI 5G applications

5G applications

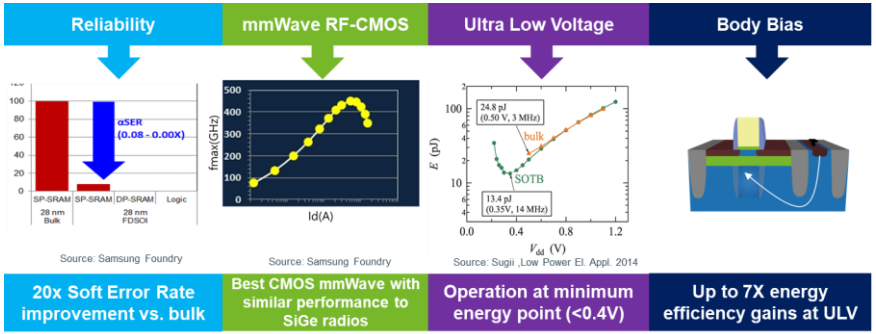
Broadband access network & high data rate:
Best in class RF performances



Massive object connectivity
Power efficiency

Mission safety
Reliability

FD-SOI: differentiating performance at device level



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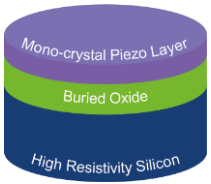
Piezo-On-Insulator (POI): the ideal substrate for SAW filters

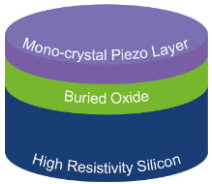
Product description

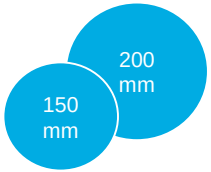


150 mm

Versatile product roadmap

- Device layer : Lithium tantalite or Lithium Niobate

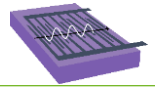
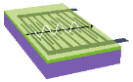
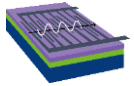




Expertise :
Smart Cut™, materials, Acoustics FoM

200-mm to support filter pricing roadmap

Best value proposition for 5G filters

	SAW	TC-SAW	BAW	POI
				
Energy efficient	=	=	+	+
New 5G band (wide >200Mhz)	-	-	+	=
Temperature stabilty	-	+	=	+
Cost	+	=	-	=
Area	=	=	=	+
Volume manufacturing	+	+	=	+

\+ optimum = suitable - not suitable

Source: Soitec analysis

Soitec manufacturing

Bernin 3
150mm

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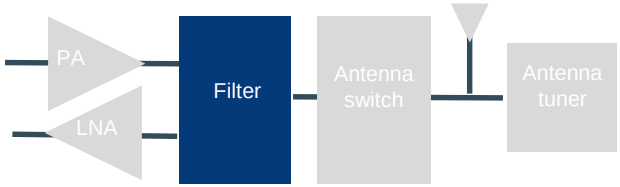
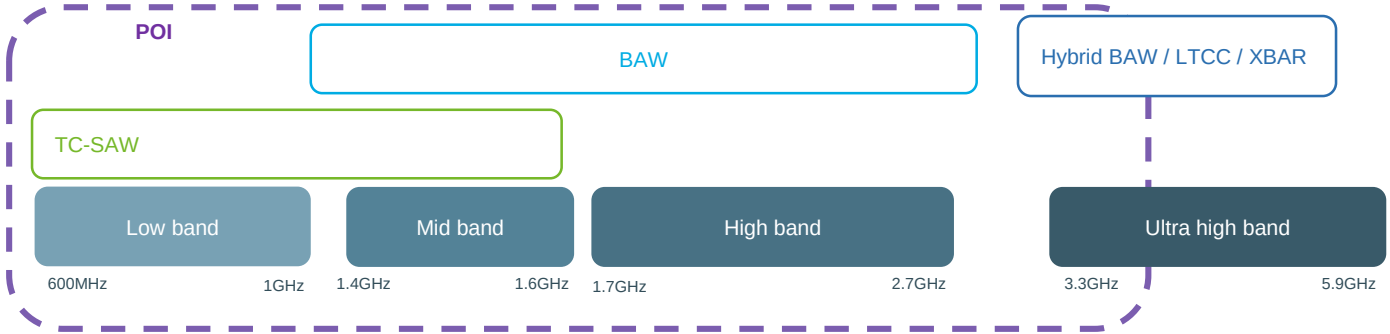
POI: a new paradigm addressing 5G

For all FEM in 5G smartphones
Ideal for 5G mid bands but not only!





› 2017-2019: historical peak of new acoustics patents for 5G filters (> 600)

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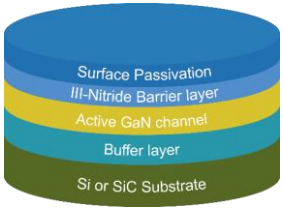
GaN for 5G

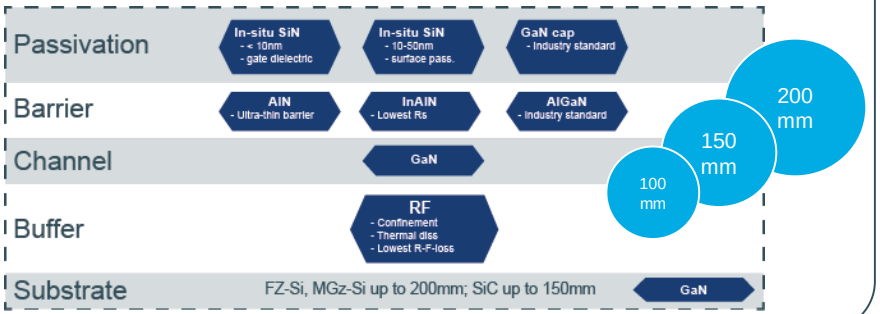
Product description

(Al,In,Ga)N Epi layer stack deposited on Silicon or Silicon Carbide wafer



Product roadmap

Soitec's toolbox for RF GaN product differentiation



Value proposition for base station PA

	LDMOS	GaN	SOI/CMOS
5G sub 6GHz PA	=	+	-
5G mmW PA >30dBm	-	+	-
5G sub 6GHz Cost	+	=	n.a
5G mmW PAs solution cost	n.a	=	+
Area	=	+	=

\+ optimum = suitable - not suitable

Source: Soitec, MACom analysis

Soitec manufacturing

Hasselt (Belgium)
GaN/Si up to 200mm; GaN/SiC up to 150-mm

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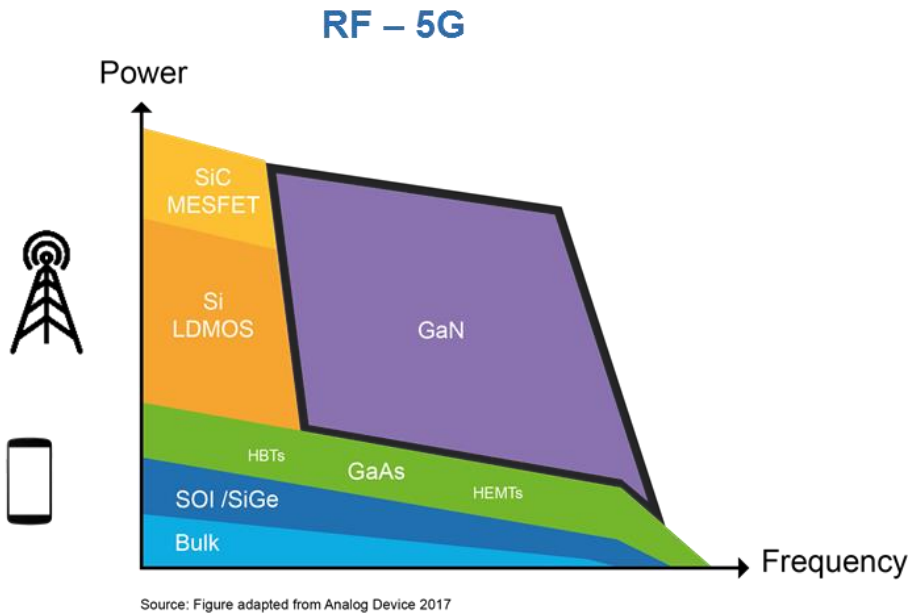
GaN for 5G



Source: Figure adapted from Analog Device 2017

- Cellular base stations (>5W power amplifier), MIMO antennas
  - GaN - becoming mainstream for 4G / 5G <6GHz and mmW
- Cellular handset (<3W Power amplifier)
  - GaAs – mainstream technology today for 4G/ 5G <6Ghz
  - GaN/Si – technology potential to enter the market

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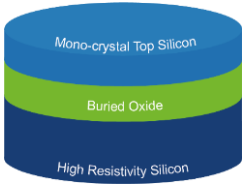
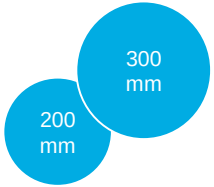
Photonics-SOI for 5G

Product description

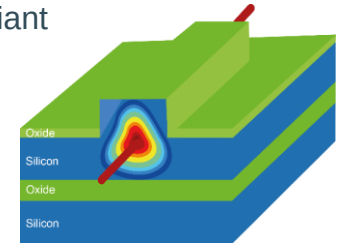


Bernin 1 & 2
200mm – 300mm

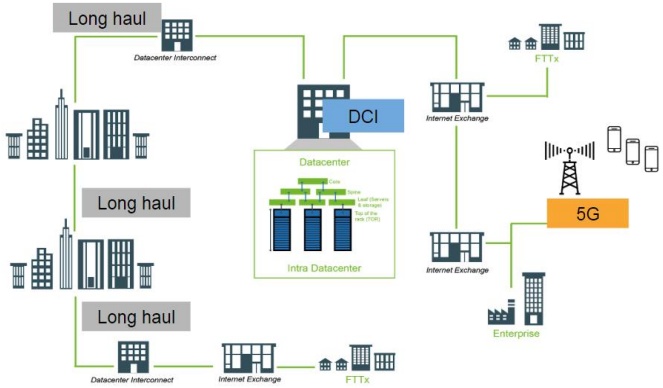


Product value proposition

- Integration platform for complex optical function using CMOS fab
- High speed modulation compliant
- Low loss wave guide
- Scalable solution for:
  - Integration
  - Performance
  - Cost



5G applications
100/400 GbE for wireless backhaul



Silicon photonics main market is in data center (not considered as a 5G market segment

Soitec manufacturing

Bernin 1	Bernin 2
200mm	300mm

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Your attention is drawn to the risk factors described in Chapter 2 of the Document de Référence. A review of these risk factors has been conducted after the closing of FY'20 first half and no new risk was found. This document contains summary information and should be read in conjunction with the Document de Référence and the FY'20 half-year report. In the event of a discrepancy between this document and the Document de Référence or the FY'20 half-year report, the Document de Référence or, as the case may be, the FY'20 half-year report, shall prevail.

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