Impact of SOI technology and its European Ecosystem on upcoming 5G

François BRUNIER, SOITEC
Partnership Program Manager

1 Soitec

Soitec – Designer & Manufacturer of Innovative Semiconductor Material

"We design and deliver innovative substrates & solutions to enable our customers' products shaping everyday life"

1,450 | **Employees Worldwide**
GLOBAL PRESENCE

4 | **High-growth Markets**
SMARTPHONES, AUTOMOTIVE, CLOUD & INFRASTRUCTURE, IOT

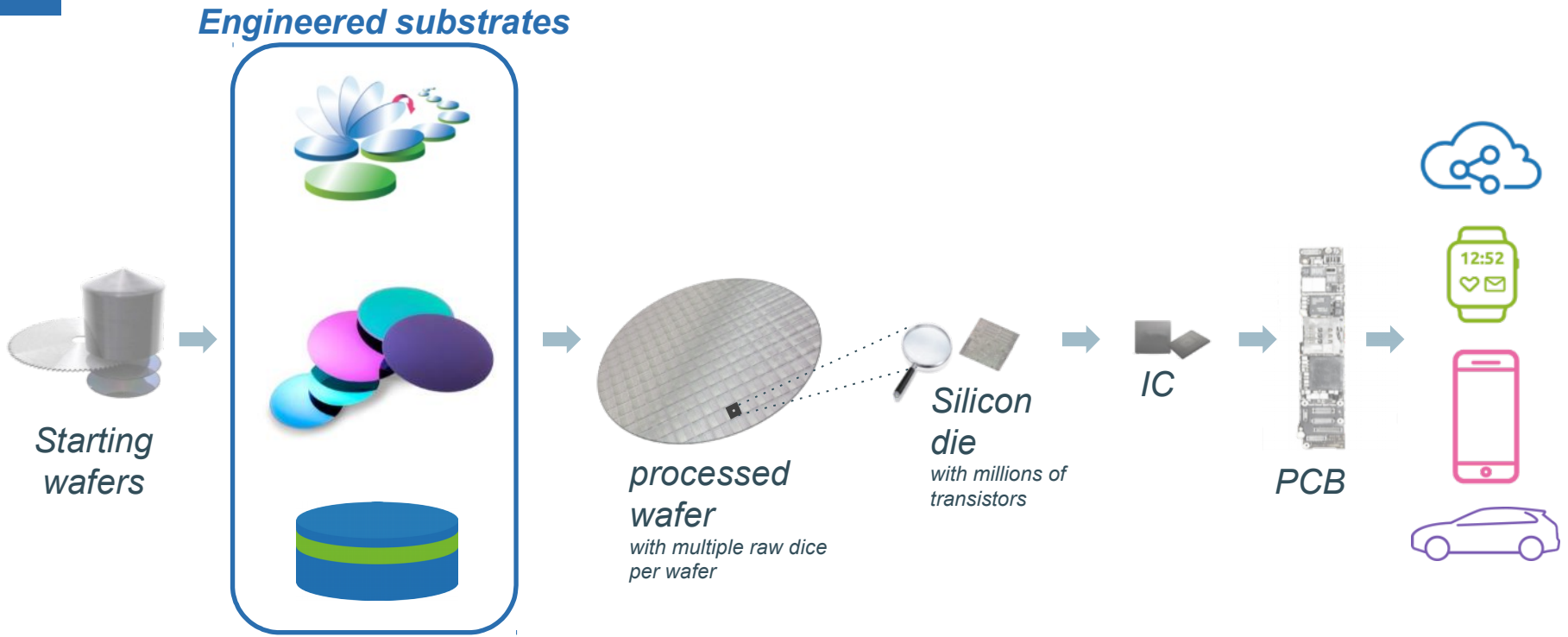
2 | **Unique Technologies**
SMART CUT, SMART STACKING

Core expertise
Epitaxy, Compound semiconductors

6 | **Wafer fabs**
300-mm – France (Bernin II) + Singapore*
200-mm – France (Bernin I) + China (via Simgui)
150 mm – France (Bernin III)
150 – 200-mm GaN Epitaxial wafers – Belgium (EpiGaN)
CAPABILITY

1 | **Largest manufacturer of engineered substrates**
LEADER

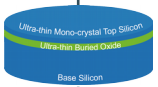
Substrates in the value chain



A broad portfolio of engineered substrates

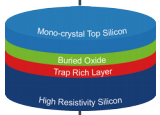
PROCESSOR & CONNECTIVITY SOC

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



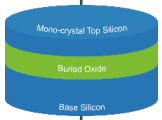
RF FRONT-END MODULE

RF-SOI
For highly efficient mobile communication



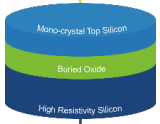
POWER

Power-SOI
For high voltage device integration



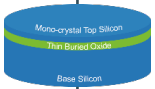
PHOTONICS

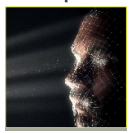
Photonics-SOI
For high perf. photonics device integration into silicon



IMAGERS

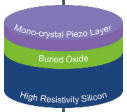
Imager-SOI
For improved imager performance in NIR





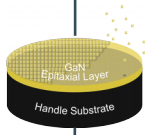
PIEZO-ON-INSULATOR

POI
For high performance 5G filters



GaN

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



Silicon-On-Insulator products

Piezo & compound products

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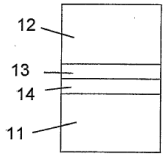
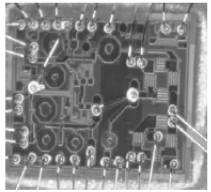
RF-SOI in 100% of Smartphone
A success story based on innovation

1992 | 2005 | 2009 | 2011 | 2012 | 2016 | 2018 & …

- Soitec Smart Cut™ SOI with CEA-LETI
- **HR-SOI** for RF with UCL



- Trap Rich SOI UCL and **Soitec IP**



- 1st commercial RF switch on SOI (Skyworks, RFMD…)

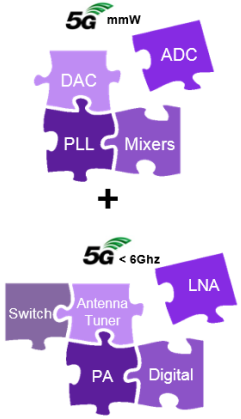
- Soitec HR-SOI: **100 thousands wafers** (8" eq)

- Soitec Trap Rich 'RFeSi' **Ramp**

- RF switch on **SOI** becomes industry **mainstream**

- 3rd Gen Soitec HR-SOI

- Soitec 300mm ramp



- Soitec RF-SOI : **moving to 1 million** wafers (8" eq)
- **FEM global development plateform**

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2 RF-SOI and FD-SOI: key technologies for upcoming 5G

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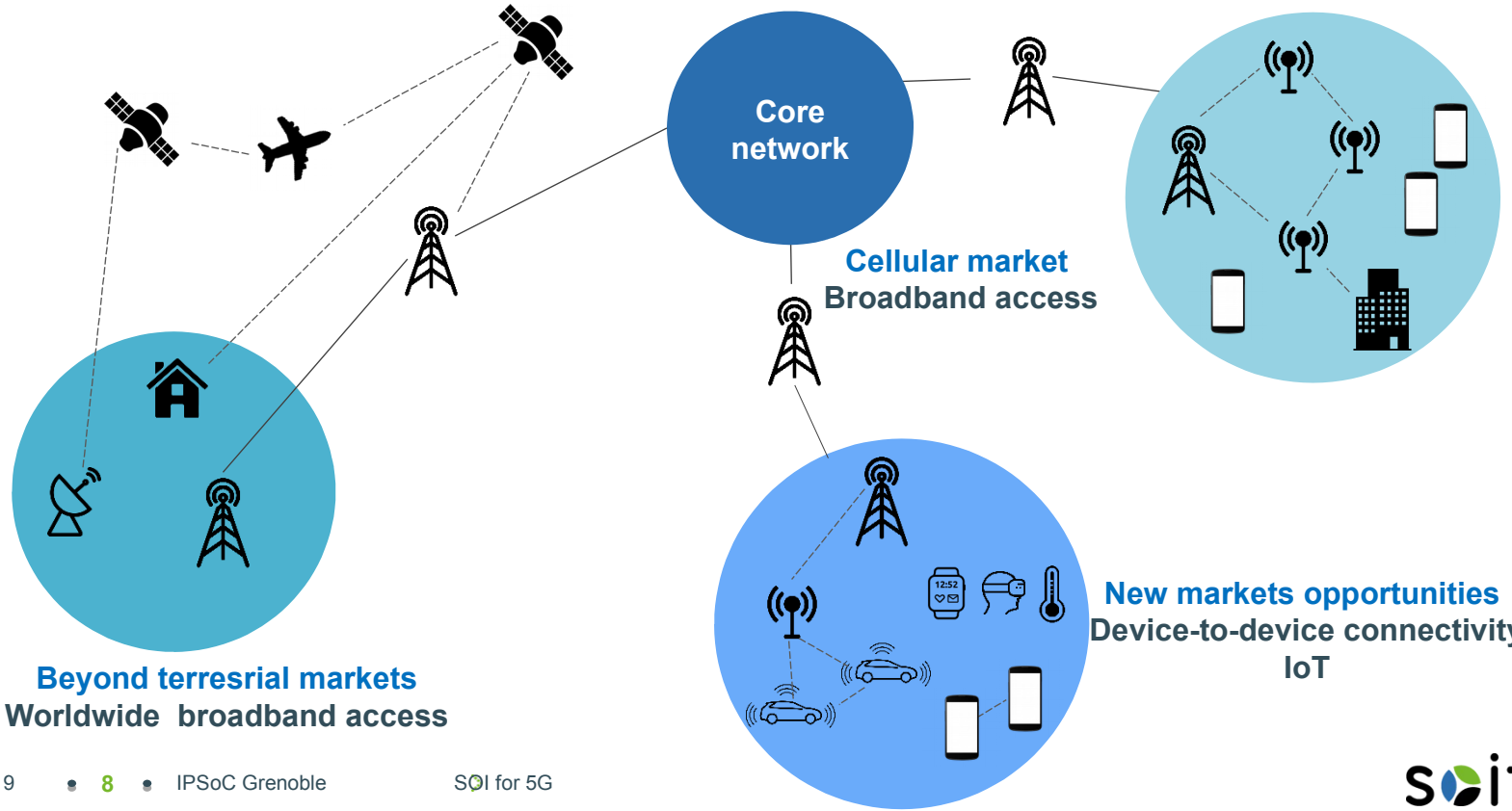
Move to 5G
To get new services and applications



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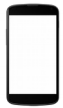
5G applications KPIs

High frequency, High RF power, High data rate, Power efficiency

Cellular market
Broadband access



5G Cellular
Handset connectivity
600Mhz-6Ghz // **26GHz - 39GHz**
100mW-1W
1M **– 10G**

5G Terrestrial
Infrastructure
600Mhz-6Ghz // **26GHz - 90GHz**
1W – 100W
10G-100G

Automotive market
Car connectivity & radar

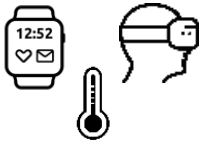
Automotive Radar
Connectivity, C-V2X
5.9GHz / 24GHz / 77-79GHz
100mW-**10W**

Gesture
Recognition
120GHz-150GHz
1mW-10mW

Satellite Com
Infrastructure
10-20GHz
10W-100W
100M-**100G**

Airplane
connectivity
1GHz / **10-20GHz**
10mW-**10W**
10M-**100G**

Beyond terrestrial markets
Worldwide broadband access



Low Power
Connectivity
100MHz-**60Ghz**
<10mW-100mW
100 – **1G**

New markets opportunities
Device-to-device connectivity
IoT

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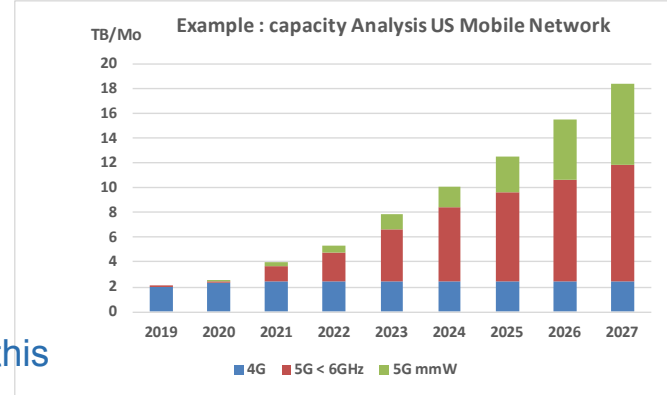
5G technology landscape a key card for Europe



- 5G is serving mobile data traffic using two spectrum
  - '5G Phase 1' : < 6Ghz ➔ keeps optimizing 4G techniques : continuous improvement
  - '5G Phase 2' : mmW(> 30GHz) ➔ disruption with opportunities for new technologies
- Europe has taken significant steps to lead global developments towards this strategic technology.
  - Radio Frequency Silicon-on-Insulator (**RFSOI**) platforms based on both **PD-SOI** and **FD-SOI**
  - **BiCMOS** and **GaN** technologies also strongly rooted in Europe
- These technologies deliver solutions for the new 5G spectrum: [<6GHz ➔ mmWave up to > 100GHz]
- PD-SOI and FD-SOI are potential standards for future 5G-mmWave handsets, base stations, Femto Cells for IoT, but also enablers in new RF domains for sensing and communications beyond 5G

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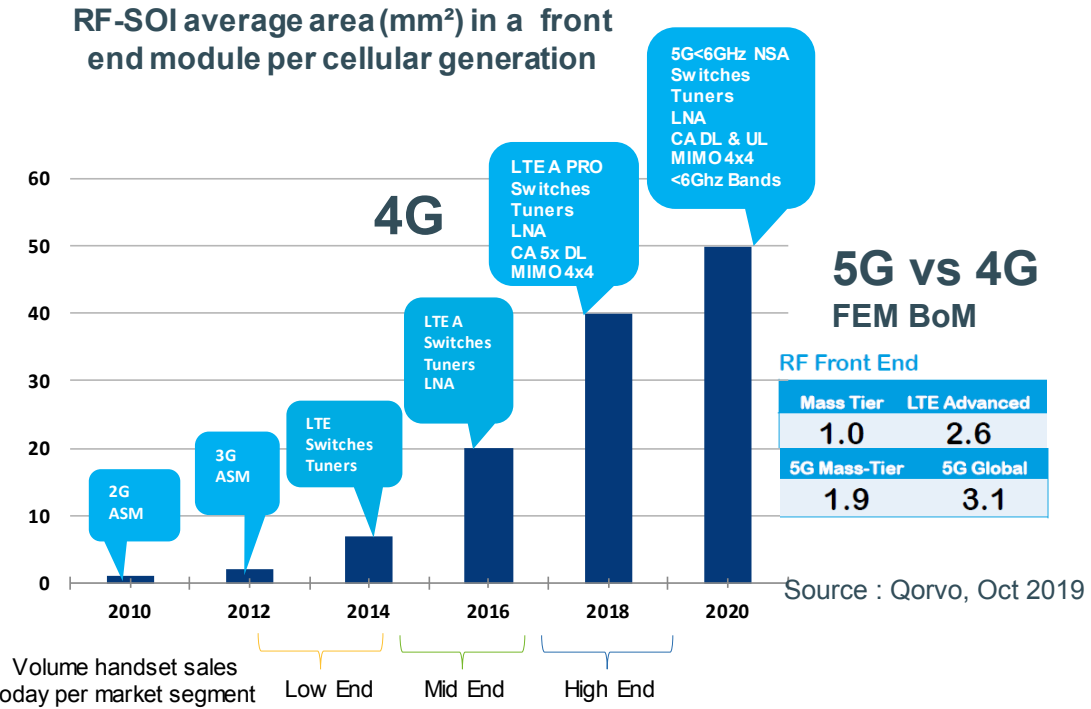
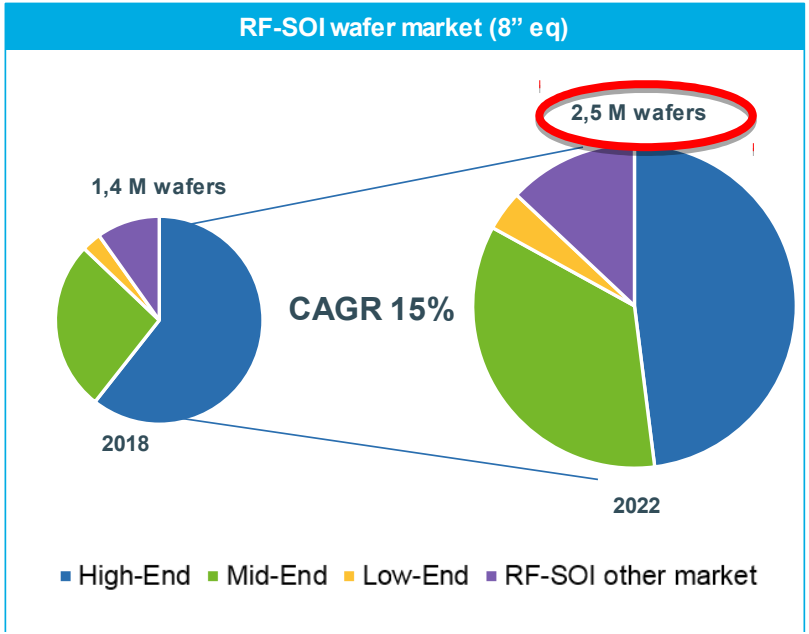
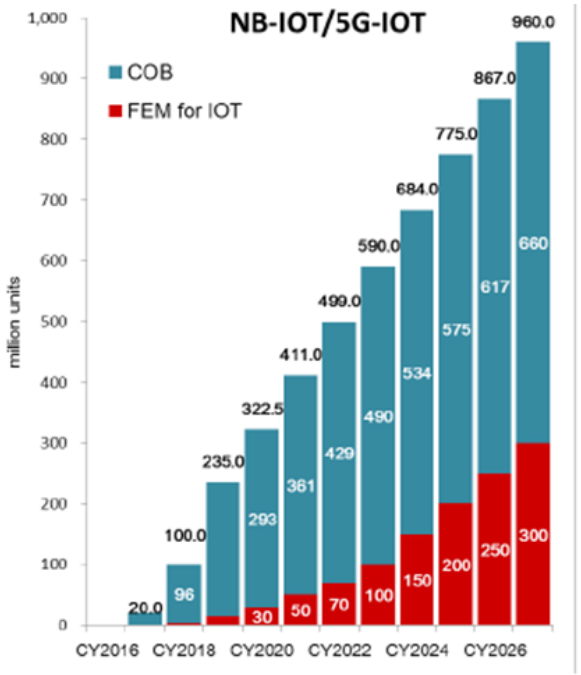
5G <6Ghz
#1 SOI market for Smartphones applications



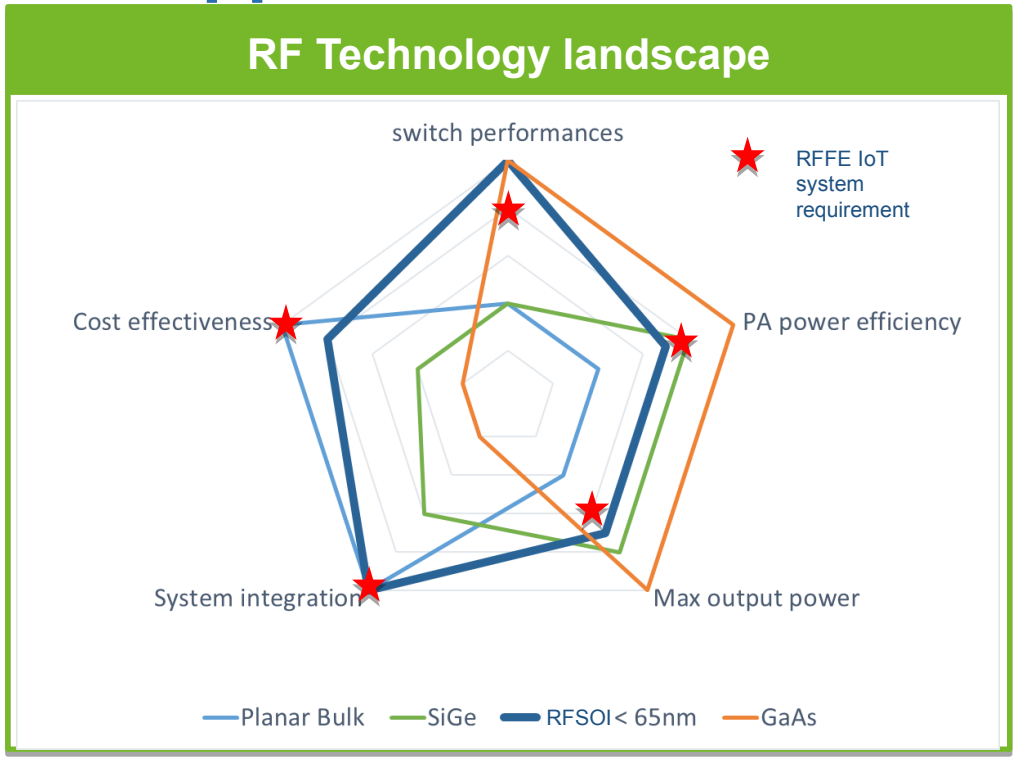


RF-SOI keeps growing at 15% CAGR beyond 2.5 M wafers

5G <6Ghz
SOI an enabler for new applications

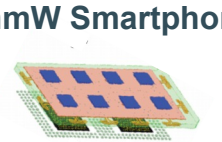


Source: NB-IoT RFFE forecast estimation, Navian 2019

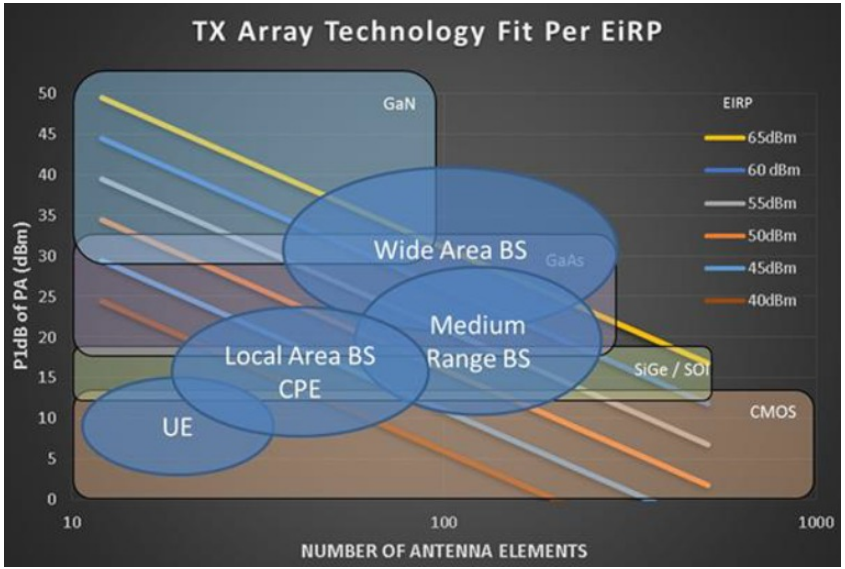


Challenge to aggregate new applications: e.g. NB-IoT FEM – 20% CAGR

5G mmW – Market opportunities and technologies positioning

Market	Challenges	Solutions
5G mmW Smartphones  **Market TAM (*) : >2 millions wafers 300mm (>2 SOI fonderies)**	Consumption Cost Integration	
5G mmW base station  **Market TAM (*) : >100K wafers 300mm**	Reliability Consumption	

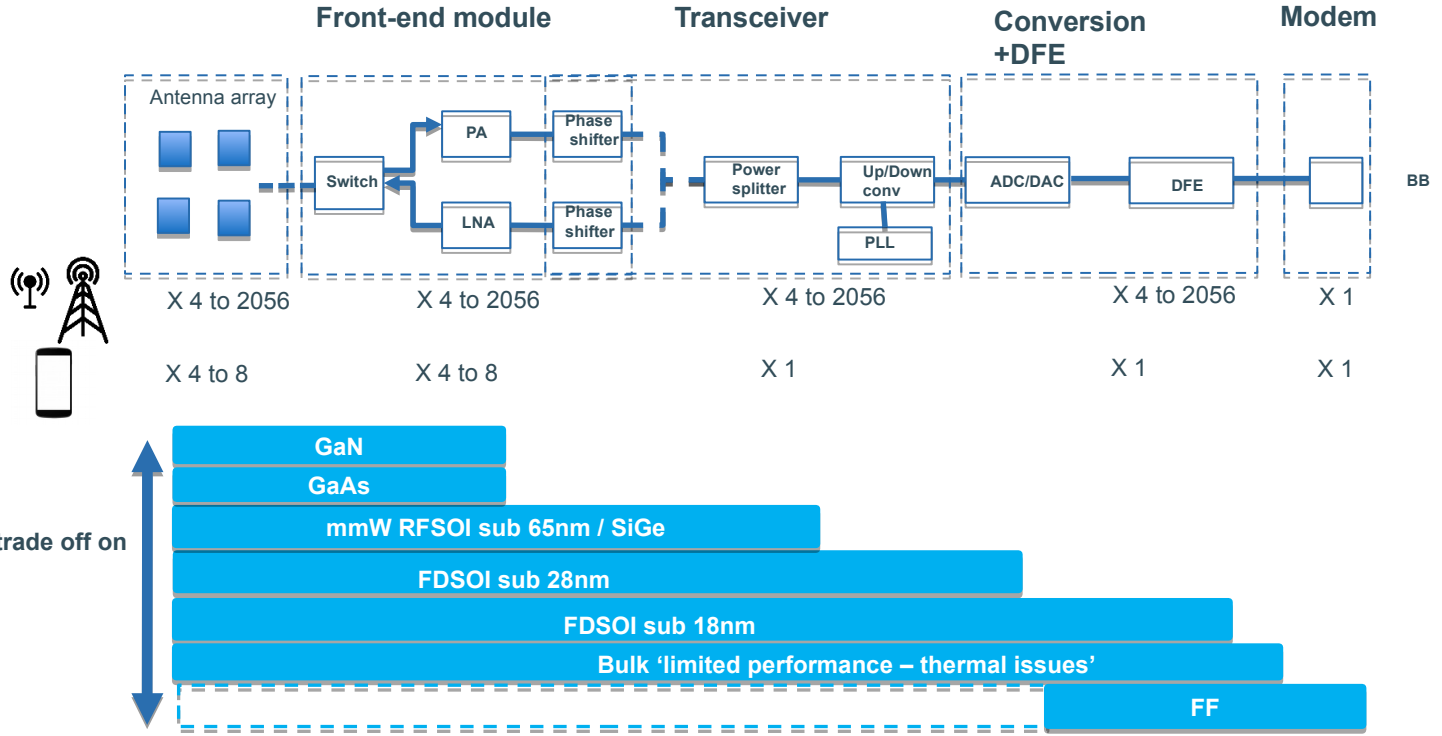
(*) : estimations Soitec (TAM for Total Available Market = 100% market share, 100% market adoption)



IWPC 5G mmW white paper, 2019

RF-SOI and FD-SOI well positioned for handset (UE) and low / medium range cells

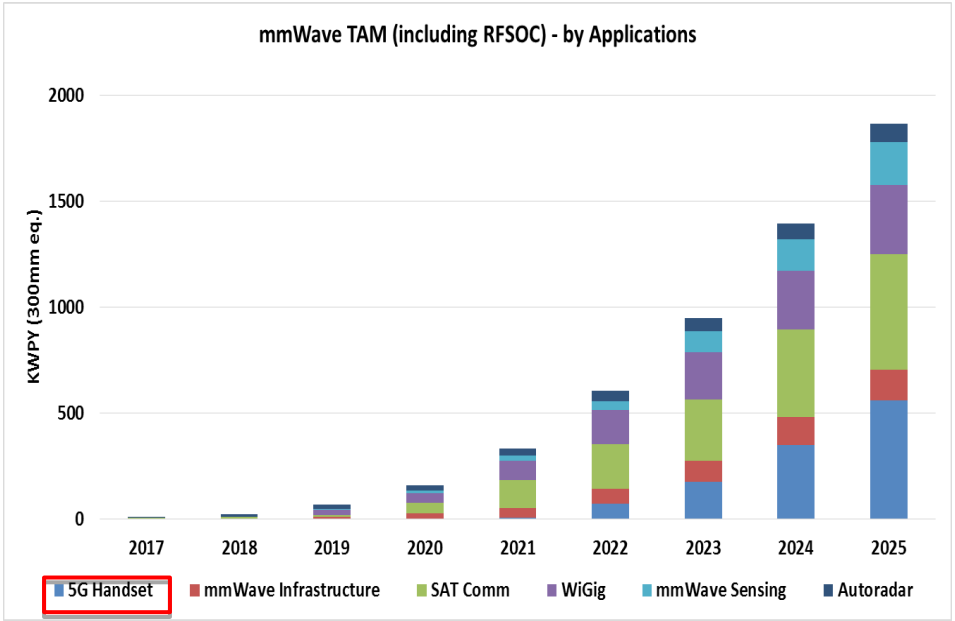
5G mmW: technology integration potential FD-SOI and RF-SOI assessed by all market leaders



Different system architecture : trade off on

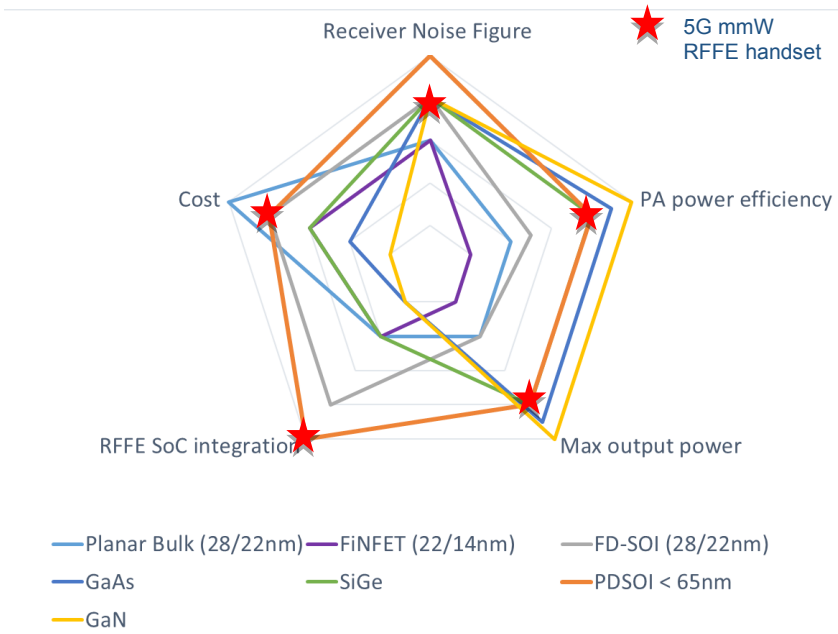
- **performance**
- **cost**
- **Area / weight**
- **Players IP / know-how**

5G mmW handset
High volume in 2022-23



Source: C-V2X (connected automotive perspective), Navian 2019

RF Technology landscape



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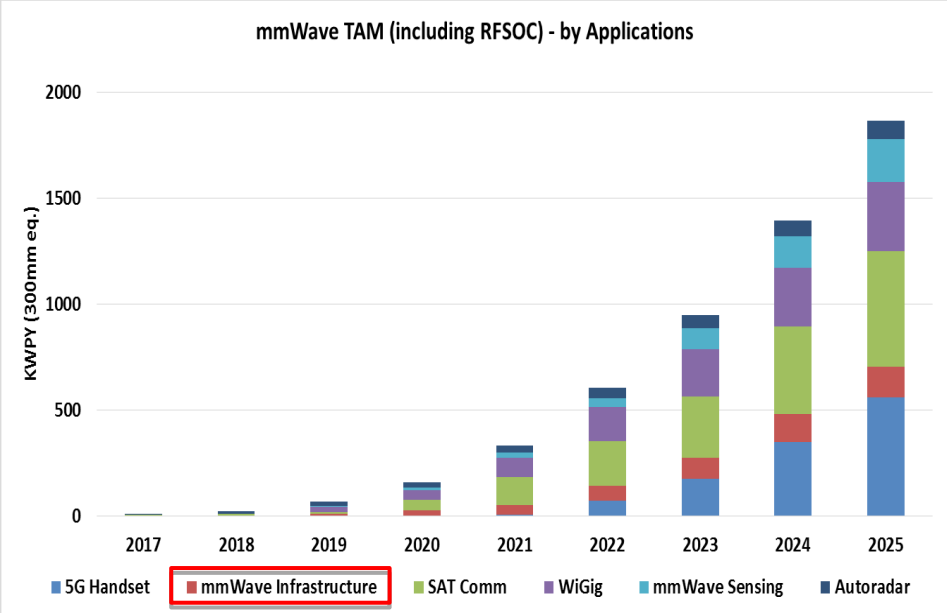
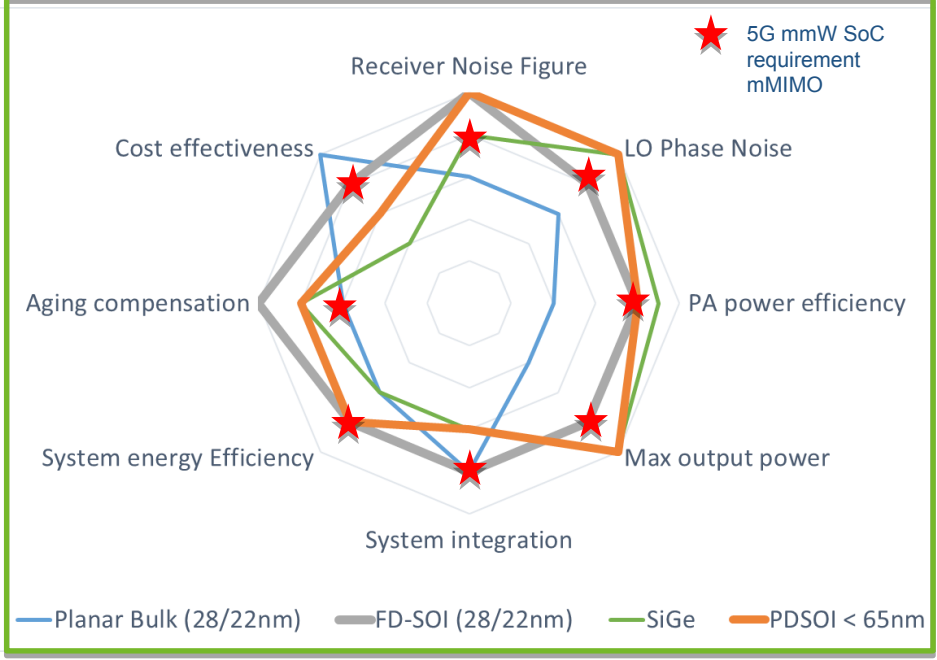
5G mmW infrastructure
RF-SOI <65nm and FD-SOI well positioned



Source: C-V2X (connected automotive perspective), Navian 2019

RF Technology landscape



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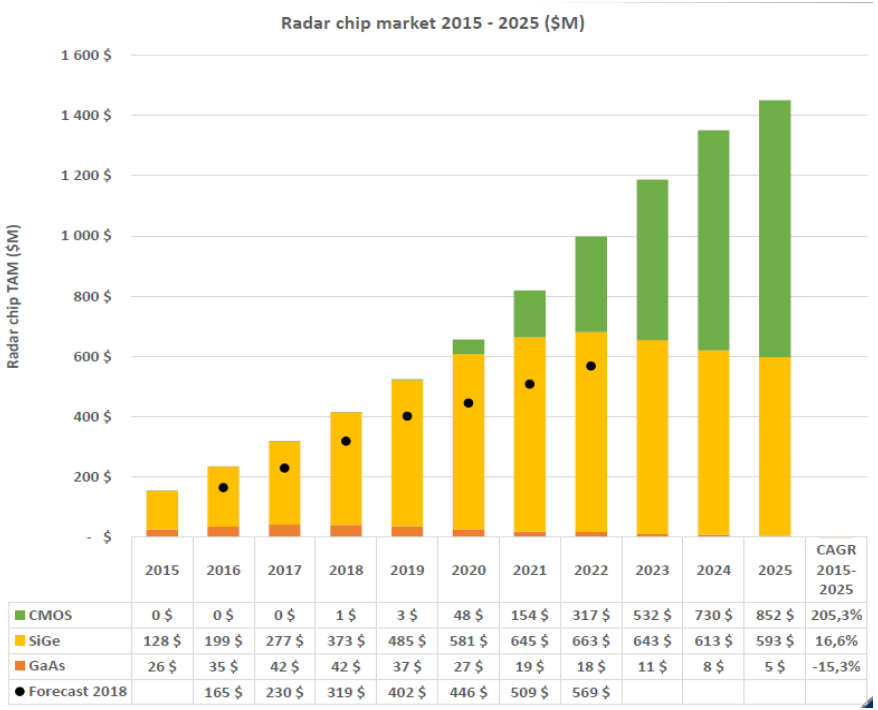
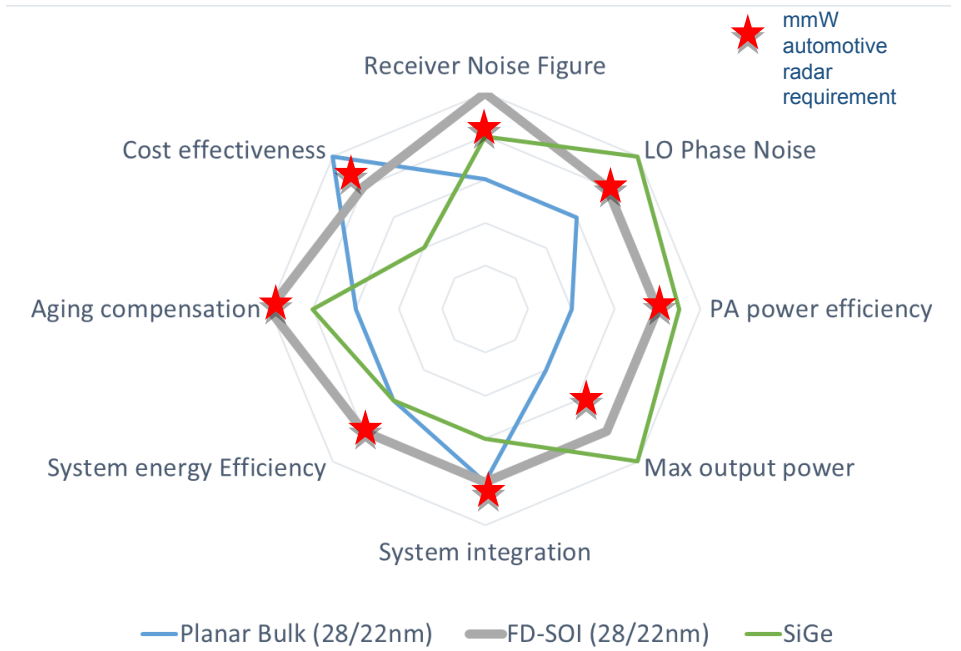
Radar
FD-SOI ideally positioned in the CMOS approach



	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	CAGR 2015-2025
CMOS	0 $	0 $	0 $	1 $	3 $	48 $	154 $	317 $	532 $	730 $	852 $	205,3%
SiGe	128 $	199 $	277 $	373 $	485 $	581 $	645 $	663 $	643 $	613 $	593 $	16,6%
GaAs	26 $	35 $	42 $	42 $	37 $	27 $	19 $	18 $	11 $	8 $	5 $	-15,3%
Forecast 2018		165 $	230 $	319 $	402 $	446 $	509 $	569 $				

Automotive Radar Market, split per technology (Source Yole 2019)

RF Technology landscape



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3 Value chain programs in EU To demonstrate competitive advantage at End-User level

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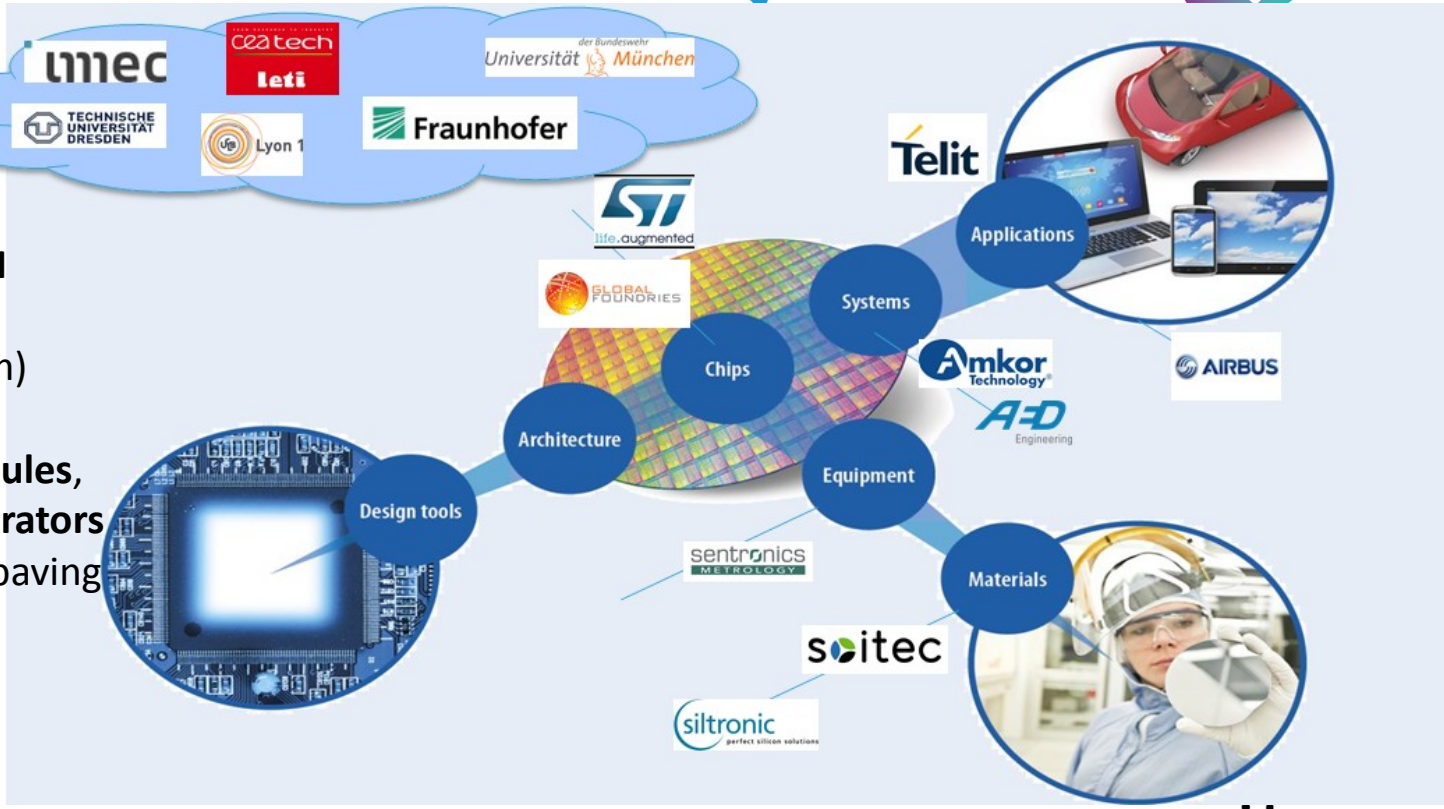
Program REFERENCE
ECSEL RIA: 2016-2019

ECSEL JU

Reference

GOAL

Develop innovative **RF-SOI substrates** & technologies (Including move to 300mm) enabling realization of **integrated Front End modules**, and system level **demonstrators** for **cellular, Aeronautics,** paving the way to 5G.



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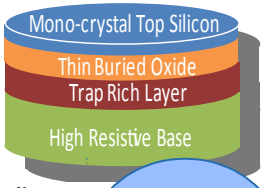
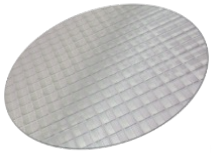
REFERENCE OUTCOMES

SOI technology SOI Foundry System design





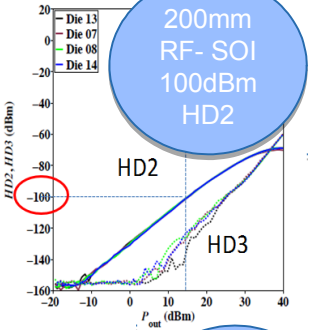
FEM integration

FOWLP materials

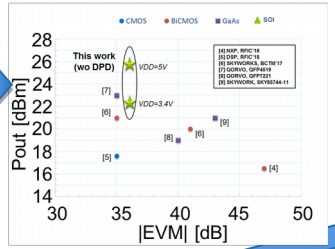
RFSOI IC packaging ATEP / Leti

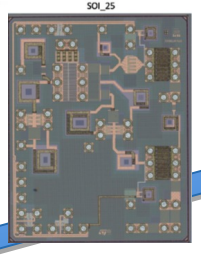
New Trap rich Materials

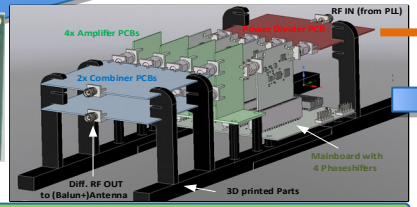
200mm RF- SOI 100dBm HD2



130nm RF-SOI (ST)







Aeronautic high-speed gate link 4.2-4.4 GHz

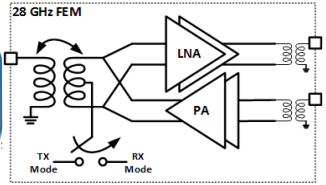
300mm EPI trap rich layer over HR bulk (> 15 kΩcm) for RF-SOI

300mm RF- SOI 4K BOX and 2K BOX

300mm Specific HR Base for FDSOI (1st trial)

1st FD-SOI HR

22-FD-SOI with HR Base (GF)



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Program OCEAN12
ECSEL IA: 2018-2021

ECSEL JU

OCEAN12

GOAL

Secure **FDSOI Roadmap in Europe**

Development of a **FDSOI** based technology platform offering the **lowest power consuming processors** and answering embedded applications requirements in automotive and aeronautics

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OCEAN12 OUTCOMES

- Demonstrators
  - Always on / Awakening system
    - Audi / CEA-Leti
  - Radar SoC
    - Bosch
  - Neural MPPA (Massive Parallel Processor Array)
    - Kalray / Airbus

Ultra low voltage operation

down to 0.4V by corner trimming/ bias trimming

>70% power reduction possible

Performance gain

by corner trimming/ bias trimming

„more bang for the buck"

Dynamic switching between situation specific optimum operating points

High performance ADAS systems: Not always need for 100% performance

→ application/ situation adaptive biasing?

New applications and usecases

due to new ultra low power sensors and microcontrollers (acoustic, MEMS, optical/ light,...)

Dr. André Blum, AUDI AG | 2018-04-26 | SOI Silicon Valley Symposium, Santa Clara, CA

Ecosystem strengthening continues
New proposal in 2019

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BEYOND5

GOAL

Aaccomplish sustainable **RFSOI** and **FDSOI/RF** platforms to cover the frequency range **from 0.7GHz to 120GHz**, and prove the technical advantage of SOI in **Nb-IoT, V2X, 5G infrastructure, Contact-less USB and Radars** (Interior / interior).

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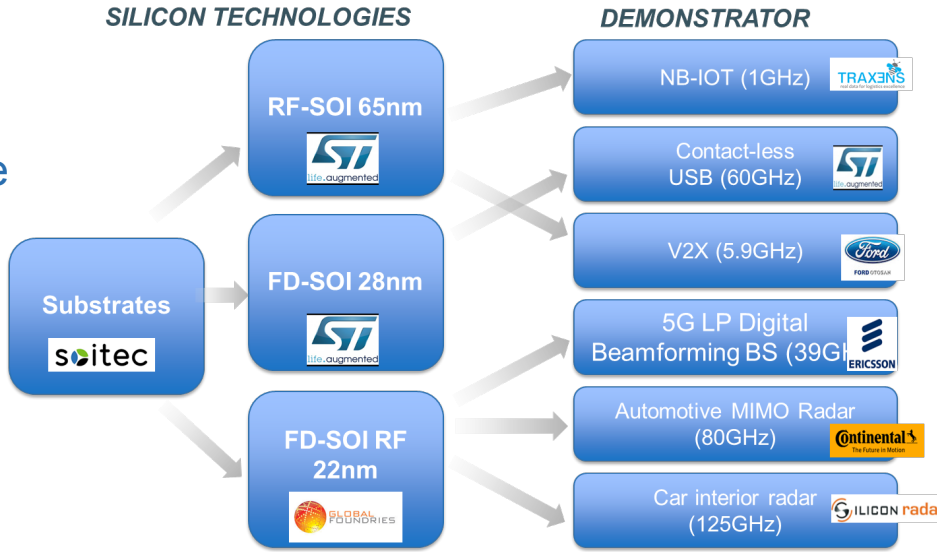
BEYOND5 Challenges

- Further develop RF-SOI as a 5G sub 6GHz standard with potential communication up to 28GHz
- Further develop FD-SOI towards a 5G mmWave standard but also other applications including sensors and AI based on:
  - Higher integration potential
  - High frequency performance and Cost efficiency
  - Best in class for density, power and speed.
- **Demonstrate European technological sovereignty for 5G infrastructure / IoT, automotive communications and intelligent RF sensors**



TAKE AWAYS

- Innovation in Microelectronics starts at substrate and material level
- RF-SOI and FD-SOI design platform can aggregate Automotive, IoT, Air and Space fast growing markets
- "Value chain model" in EU Programs is a motorway to:
  - accelerate co-innovation and the market adoption
  - strengthen demand in Europe and attract manufacturing capabilities
- Europe has the potential to cover the strategic part supply chain for 5G, from substrate to key components and sub-systems and demonstrate its technological independency.
- ECSEL JU is critical to structure this collaborative ecosystem.

THANK YOU

Financial support

R&D work and **F**irst **I**ndustrialization **D**eployment (FID) developments for the above presented content are supported by the French Government in the frame of the **I**mportant **P**roject of **C**ommon **E**uropean **I**nterest (**IPCEI**) for microelectronics and as part of Nano 2022.

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IPCEI on MICROELECTRONICS

The projects OCEAN12 and REFERENCE have received funding from ECSEL Joint Undertaking (JU) under grant agreement 783127 and 692477 respectively

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European Commission