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

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Soitec – Designer & Manufacturer of Innovative Semiconductor Material

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

1. Largest manufacturer of engineered substrates
   LEADER

2. Unique Technologies
   SMART CUT, SMART STACKING

3. Employees Worldwide
   GLOBAL PRESENCE

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

5. Core expertise
   Epitaxy, Compound semiconductors

6. High-growth Markets
   SMARTPHONES, AUTOMOTIVE, CLOUD & INFRASTRUCTURE, IOT

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Substrates in the value chain

**Engineered substrates**

Starting wafers → Processed wafer with multiple raw dice per wafer → Silicon die with millions of transistors → IC → PCB

- Silicon die
- Engineered substrates
- Starting wafers
- Processed wafer
- Silicon die with millions of transistors
- IC
- PCB
A broad portfolio of engineered substrates

PROCESSOR & CONNECTIVITY
SOC
FD-SOI
For power-efficient integration of digital/analogue/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 performance photonics device integration into silicon

IMAGERS
Imager-SOI
For improved imager performance in NIR

PIEZO-ON-INSULATOR
POI
For high performance 5G filters

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

Silicon-On-Insulator products
Piezo & compound products
RF-SOI in 100% of Smartphone
A success story based on innovation

- 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
RF-SOI and FD-SOI: key technologies for upcoming 5G
Move to 5G
To get new services and applications

Beyond terrestrial markets
Worldwide broadband access

Core network

Cellular market
Broadband access

New markets opportunities
Device-to-device connectivity
IoT
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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SDI for 5G
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
5G <6Ghz
#1 SOI market for Smartphones applications

RF-SOI average area (mm²) in a front end module per cellular generation

5G vs 4G
FEM BoM

Source : Qorvo, Oct 2019

RF-SOI wafer market (8” eq)

2,5 M wafers
1,4 M wafers

CAGR 15%
2018
2022

High-End  Mid-End  Low-End  RF-SOI other market

Volume handset sales today per market segment

High End  Mid End  Low End

RF-SOI keeps growing at 15% CAGR beyond 2.5 M wafers
5G <6Ghz
SOI an enabler for new applications

Challenge to aggregate new applications: e.g. NB-IoT FEM – 20% CAGR
5G mmW – Market opportunities and technologies positioning

**Market**

- **5G mmW Smartphones**
  - Market TAM (*) : >2 millions wafers
  - 300mm (>2 SOI fonderies)

- **5G mmW base station**
  - Market TAM (*) : >100K wafers
  - 300mm

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

**Challenges**

- Consumption
- Cost
- Integration
- Reliability
- Consumption

**Solutions**

- 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

- GaN
- GaAs
- mmW RF-SOI sub 65nm/SiGe
- FDSOI sub 28nm
- FDSOI sub 18nm
- Bulk ‘limited performance – thermal issues’
- FF
5G mmW handset
High volume in 2022-23

RF Technology landscape

Source: C-V2X (connected automotive perspective), Navian 2019
5G mmW infrastructure
RF-SOI <65nm and FD-SOI well positioned

RF Technology landscape

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

FD-SOI ideally positioned in the CMOS approach

Automotive Radar Market, split per technology (Source Yole 2019)
Value chain programs in EU
To demonstrate competitive advantage at End-User level
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.
**REFERENCE OUTCOMES**

SOI technology | SOI Foundry | System design

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**New Trap rich Materials**

- **200mm RF-SOI**
- **130nm RF-SOI**
- **HD2**

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

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

**1st FD-SOI HR**

**22-FD-SOI with HR Base (GF)**

**Aeronautic high-speed gate link 4.2-4.4 GHz**

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**FEM integration**

**FOWLP materials**

**RFSOI IC packaging**

**ATEP / Leti**

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**Mono-crystal Top Silicon**

**Thin Buried Oxide**

**Trap Rich Layer**

**High Resistive Base**

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SOI for 5G
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
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,...)
Ecosystem strengthening continues
New proposal in 2019

GOAL

Accomplish 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).
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.
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