Smart Cut™ Nano Technology

Dr. Carlos Mazuré
CTO, Soitec
Chairman, SOI Industry Consortium

European Innovation Day
Tokyo, October 15, 2018

Agenda

- **A** Introduction
- **B** RF
- **C** MEMS
- **D** Takeaways

Substrate Engineering: Built-in Functionality

Device laye

Silicon

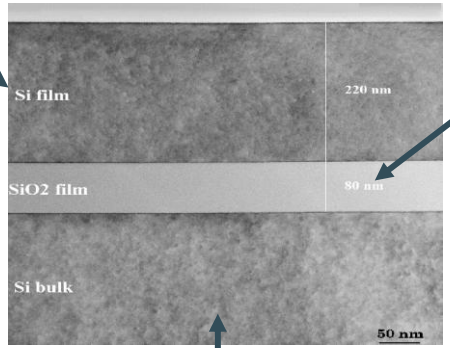
:

Strained Silicon

Germanium

III-V

.....



Buried insulat

SiO2

ONO

.....

Handle Substrat

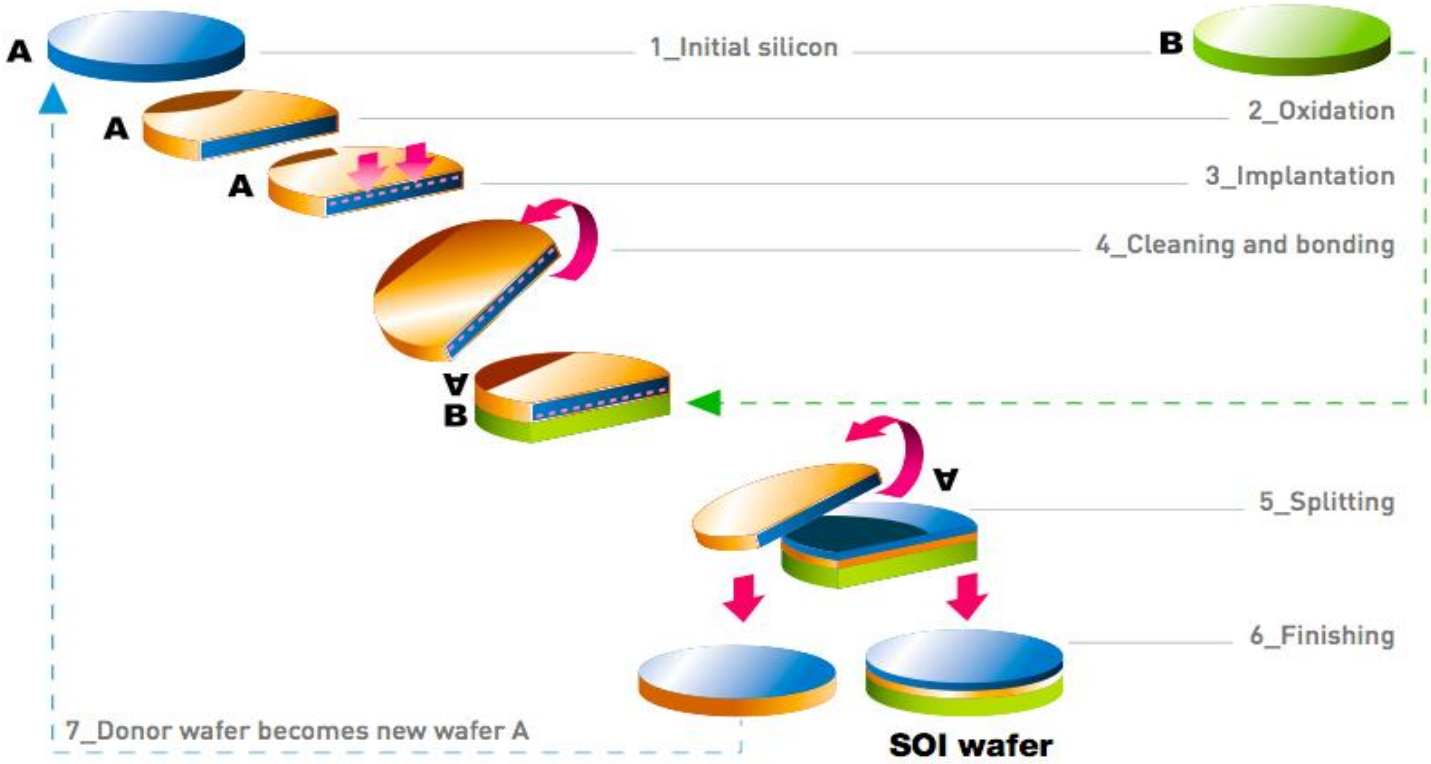
CZ Silicon

High Resistivity Si

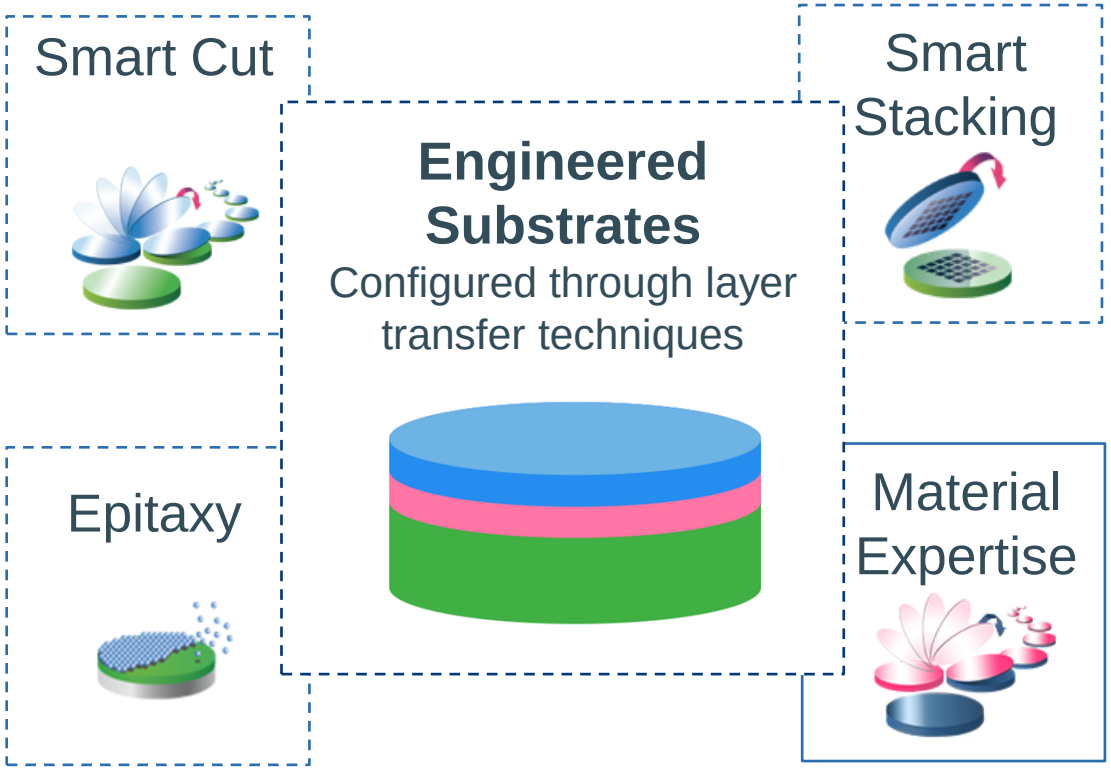
Sapphire

Glass

Smart Cut™ Technology

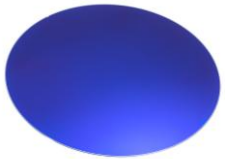


3 core technologies available and material expertise to manufacture engineered substrates

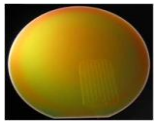


Smart Cut Flexibility

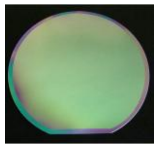
Material Options



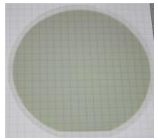
Silicon On Insulator



Silicon On Sapphire



Piezzo On Insulator

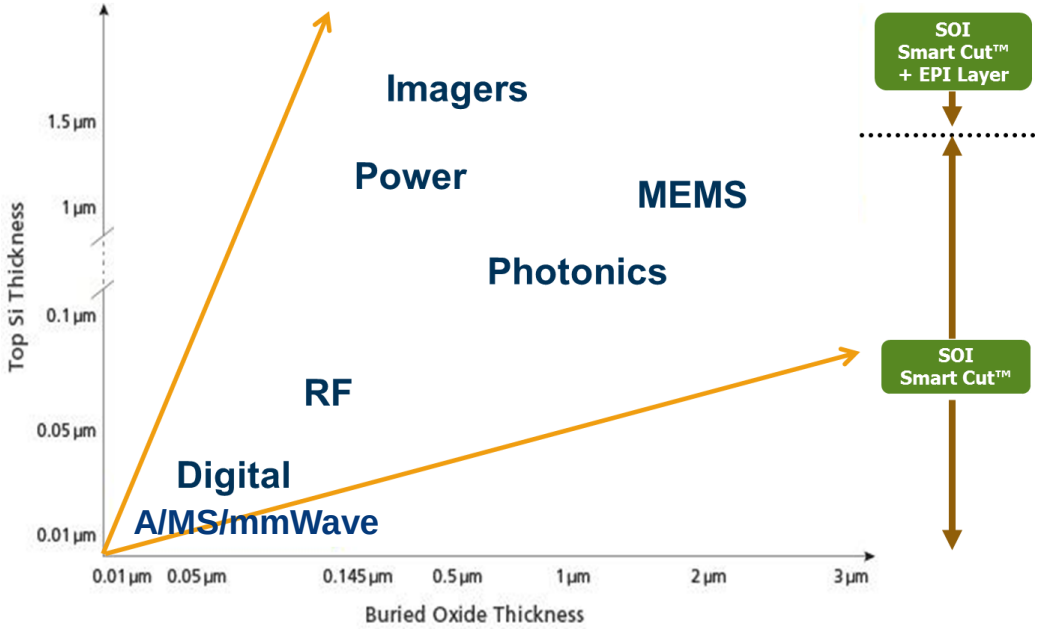


InGaN On Sapphire

InP On GaAs

…

Thickness Capabilities



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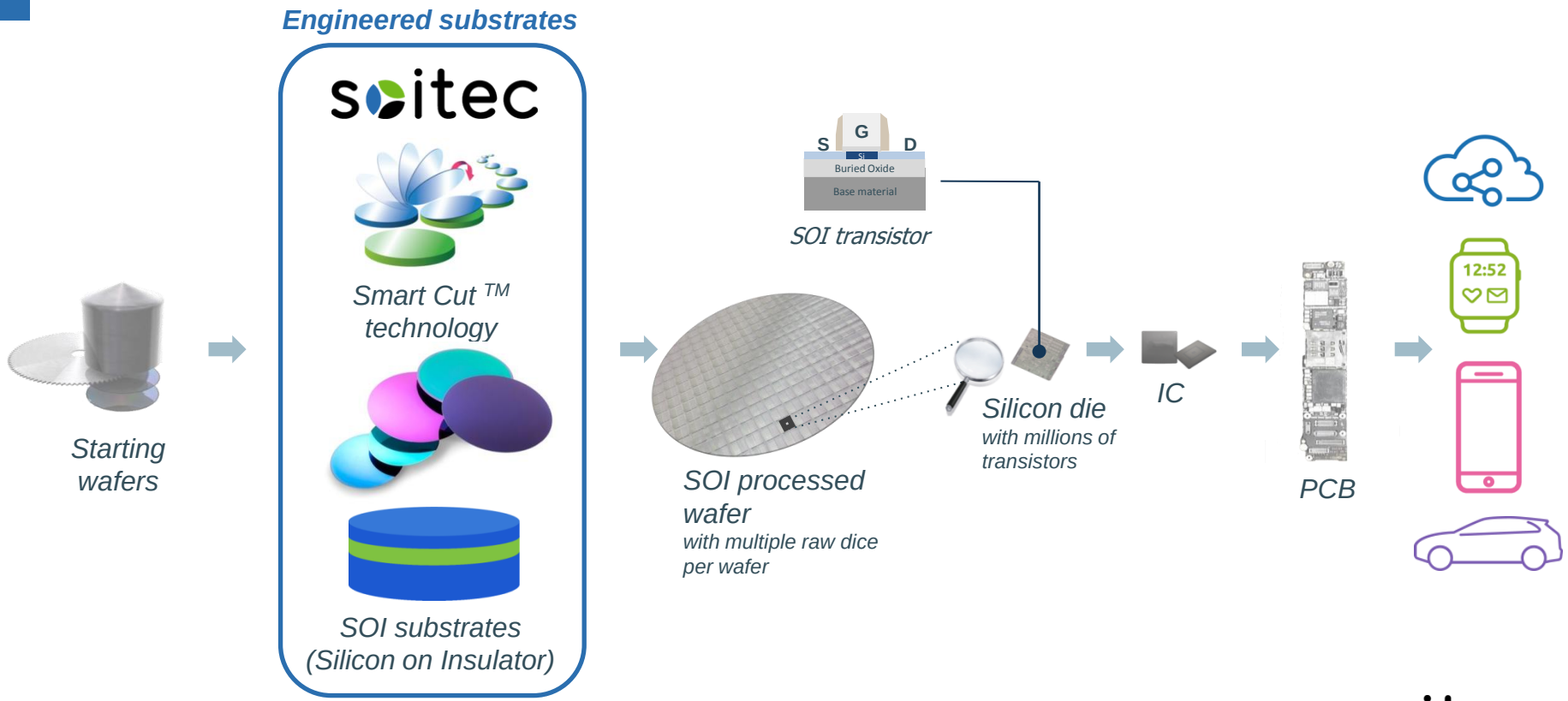
Soitec in the Value Chain



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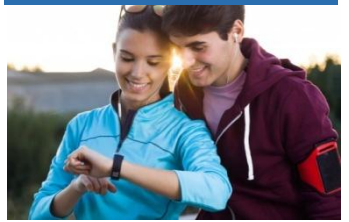
Our engineered substrates are at the heart of everyday life

Data Centers

Outstanding Performance

Longer battery life

IoT



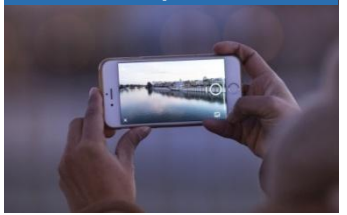
Soitec's engineered substrates

Automotive

Higher reliability

Optimized cost

Smartphones



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Soitec – A Leading Engineered Substrates Supplier addressing Large Consumer related Markets

In Production

Power	RF Front-end Module	Processor & connectivity SoC	Photonics	Imagers
Power-SOI	RF-SOI	FD-SOI	Photonics-SOI	Imager-SOI





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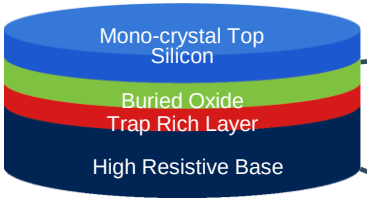
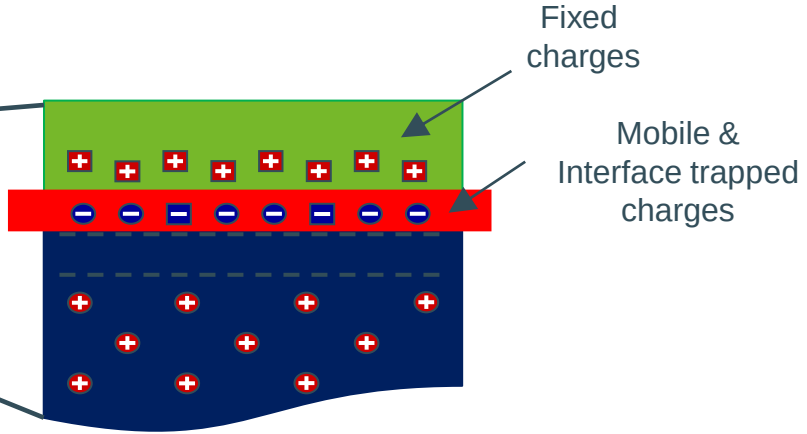
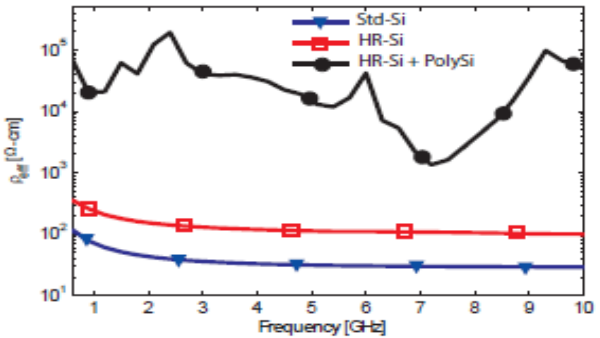
- D Takeaways

Enhanced Signal Integrity SOI - RFeSI™

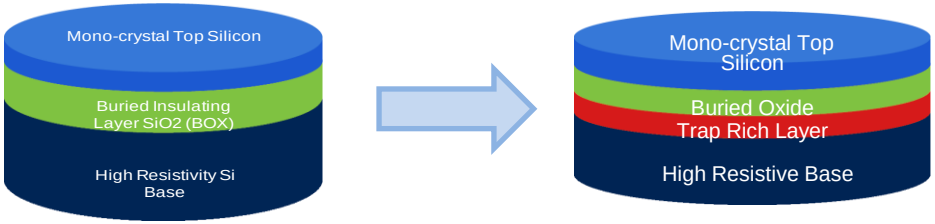
- Trap Rich layer freezes the highly conductive layer at BOX – Handle interface





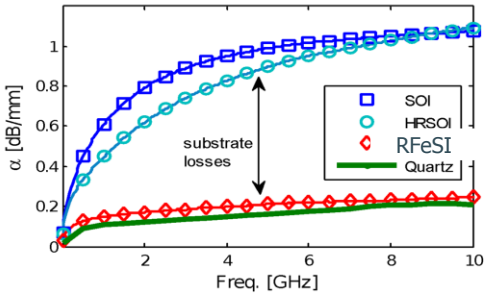


RFeSI™ addresses all FEM challenges

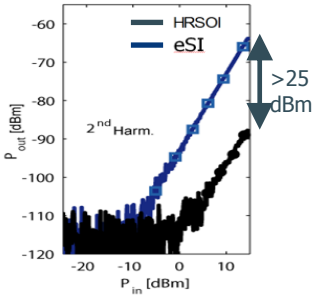


HR-SOI

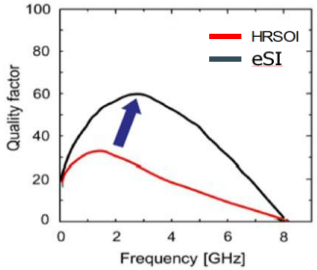
RFeSI SOI



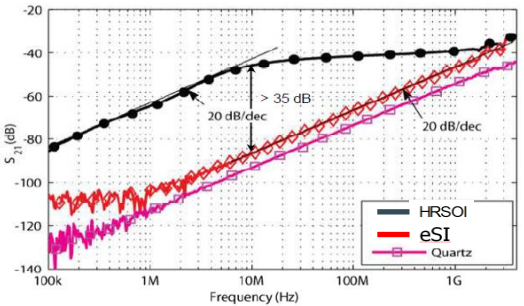
Insertion Loss



Linearity



High Q passives



Crosstalk

***Source**: UCL*

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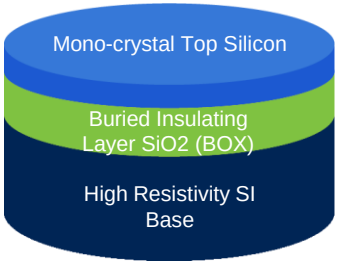
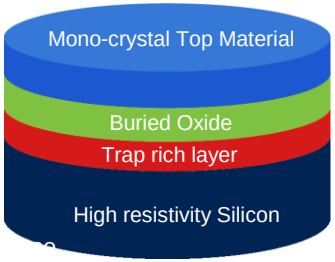
Soitec RF-SOI wafers : HRSOI & RFeSI™

HRSOI



RFeSI
Enhanced Signal Integrity

RFeSI relies on a unique Trap Rich layer that will limit high frequency signal propagation in the substrate boosting device RF performance



Manufacturing in 200mm and 300mm

Bernin 1 | Bernin 2 | Simgui | Singapore

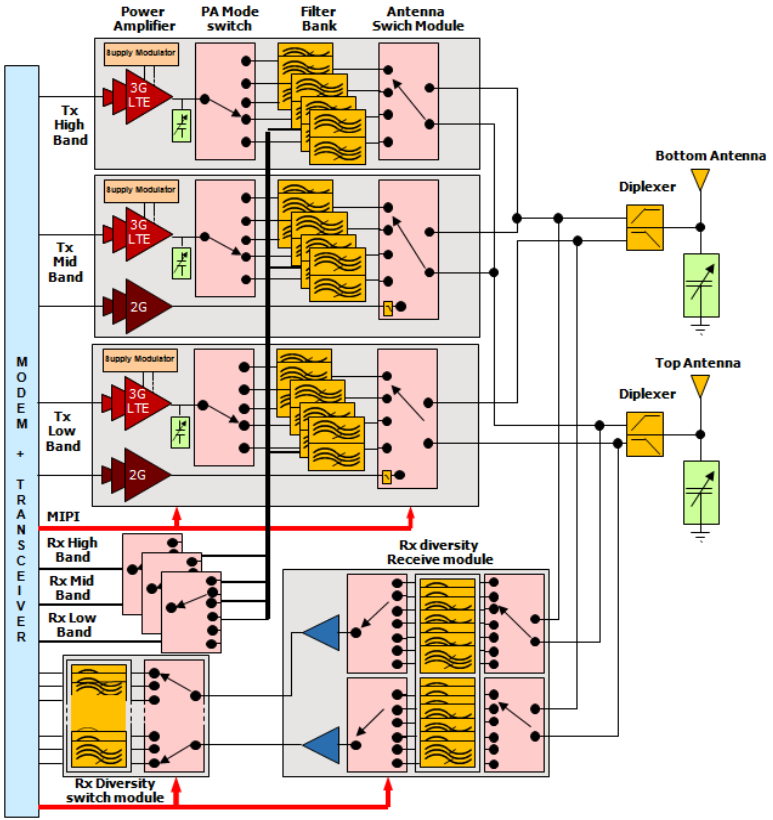
Value proposition

PERFORMANCE
› Higher Linearity
› Lower RF losses
› Lower crosstalk
› High quality passives

COST
› Lower than GaAs and MEMS
› Integration with switch, amplifiers and passives
› Available in 200/300mm

AREA
› Lower die size

4G and 5G sub <6GHz Front End Module



Switch	RF-SOI	✓
Antenna tuner	RF-SOI	✓
Diplexer	RF-SOI	✓
LNA	RF-SOI	✓
PA	RF-SOI	✓
Filters	Piezo On Insulator	✓

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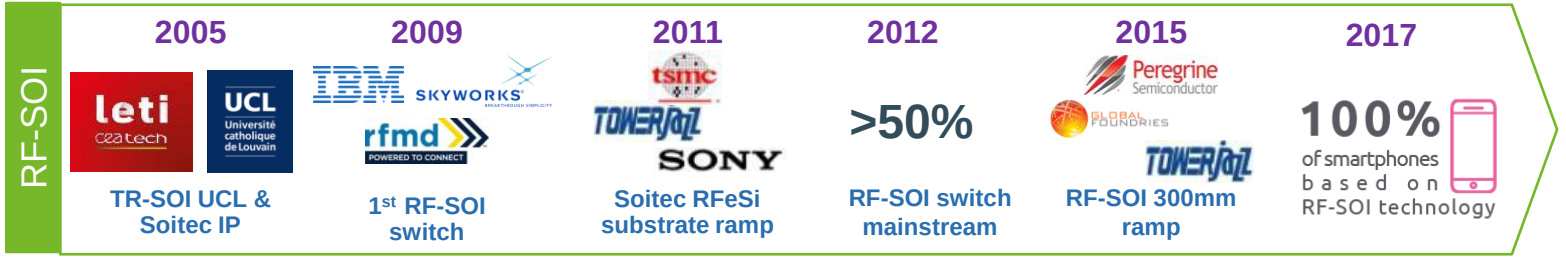
RF-SOI Innovation: From R&D to Tech Dev to Mfg

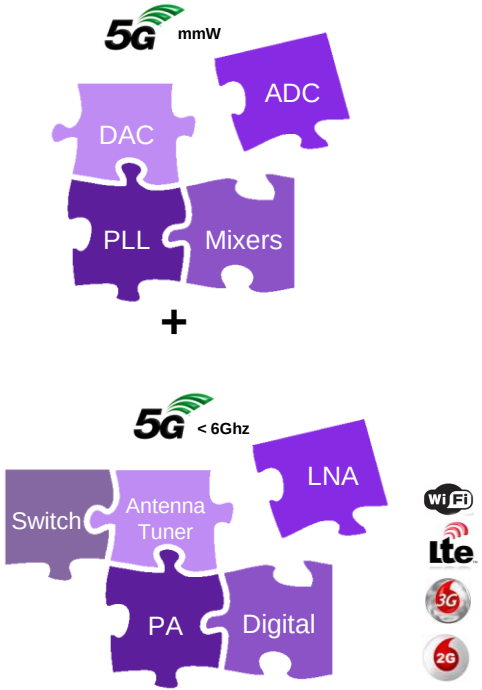


Contribution of many organizations and companies

Strong SOI ecosystem driving innovation for 4G/5G

Addressing current needs and new challenges

- FD-SOI 22/28nm
- RF-SOI 45nm
- RF-SOI 65nm
- RF-SOI 90nm
- RF-SOI 0.13um
- RF-SOI 0.18um
- RF-SOI 0.25um



> 10 foundries in HVM mode

TOWERJAZZ
GLOBAL FOUNDRIES
tsmc
life.augmented
UMC
SONY
TOSHIBA
SMIC
X-FAB MIXED-SIGNAL FOUNDRY EXPERTS
MagnaChip
HHGrace 華虹宏力
TPSCo Because Life is Analog
...

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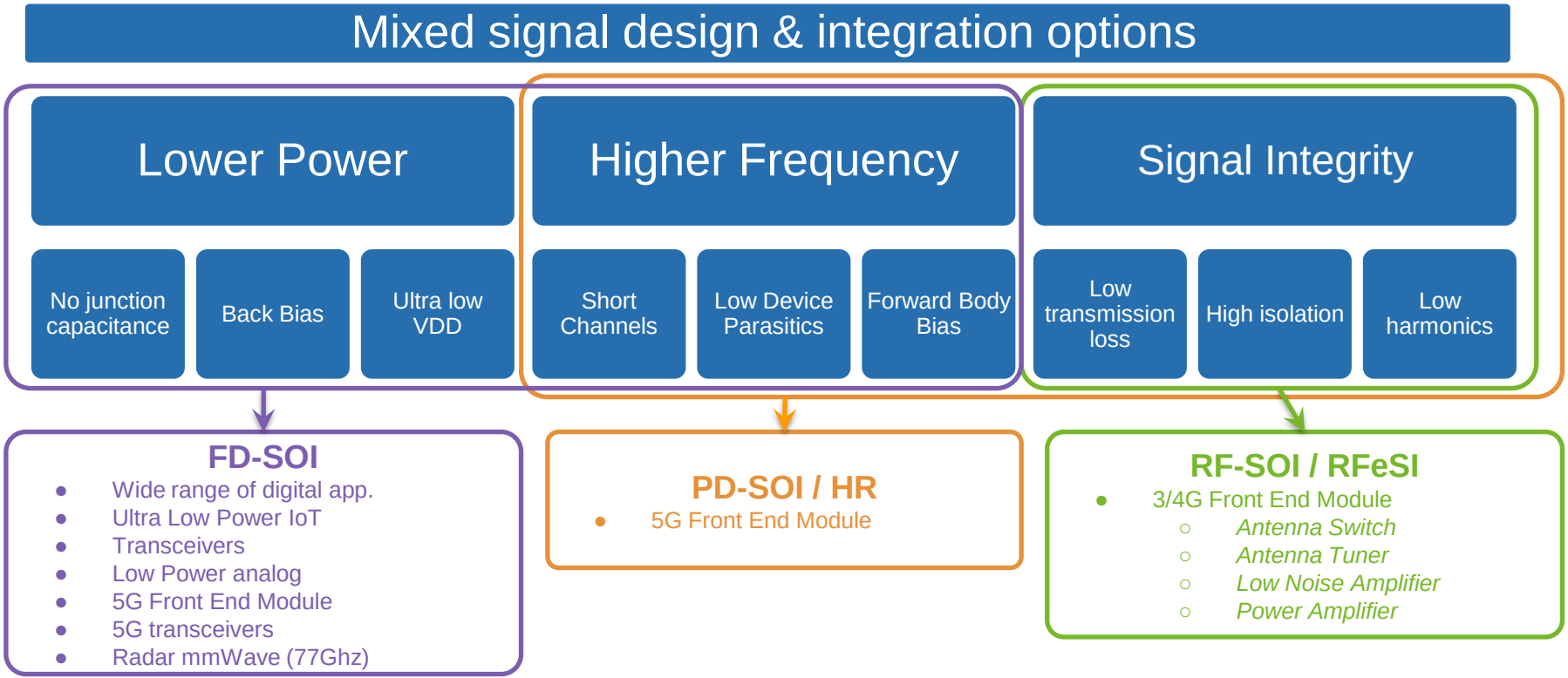
SOI mixed signal platforms for 4G & 5G



RF-SOI Innovation: From R&D to Tech Dev to Mfg

Workshop Agenda

08:00 - 09:00	Registration
	Session 1: Opening Remarks
09:00 - 09:08	Xi Wang, Director General of Shanghai Institute of Microsystem and Information Technology
09:08 - 09:15	Carlos Mazure, Chairman and Executive Director, SOI Industry Consortium
	Session 2: Keynote Speech
09:15 - 09:40	Join Hands with Industry Partners - Hop on the 5G Shuttle Together Danni Song, Project Manager, China Mobile
09:40 - 10:05	Riding the 5G Silicon Wave: How Advances in 5G Radio Architectures Benefit from RF-SOI Michael Reiha, Head of RFIC R&D, Nokia Mobile Networks
10:05 - 10:30	RFSOI Enabling the RF Wireless Front End: History, Future and Challenges Julio Costa, Director of Technology Development, Qorvo
10:30 - 11:00	Break *sponsored by* incize

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SOI Industry Consortium 1.0: Accelerator of ecosystem development

- Ecosystem focused workshops around the world
  - Oct 2009, @ IMEC, Leuven, Belgium
  - Sept 2010, @ Univ of Tokyo, Japan
  - Dec 2010, San Francisco, US
  - April 2011, Hsinchu, Taiwan
  - Feb 2012, San Francisco, US
  - Dec 2012, San Francisco, US
- Topics: technology, modeling and fabless requirements
- Contributors: academia, R&D (Institutes, Industry), EDA, Fabless

SOI Industry Consortium 2.0: Ecosystem growth and promote adoption

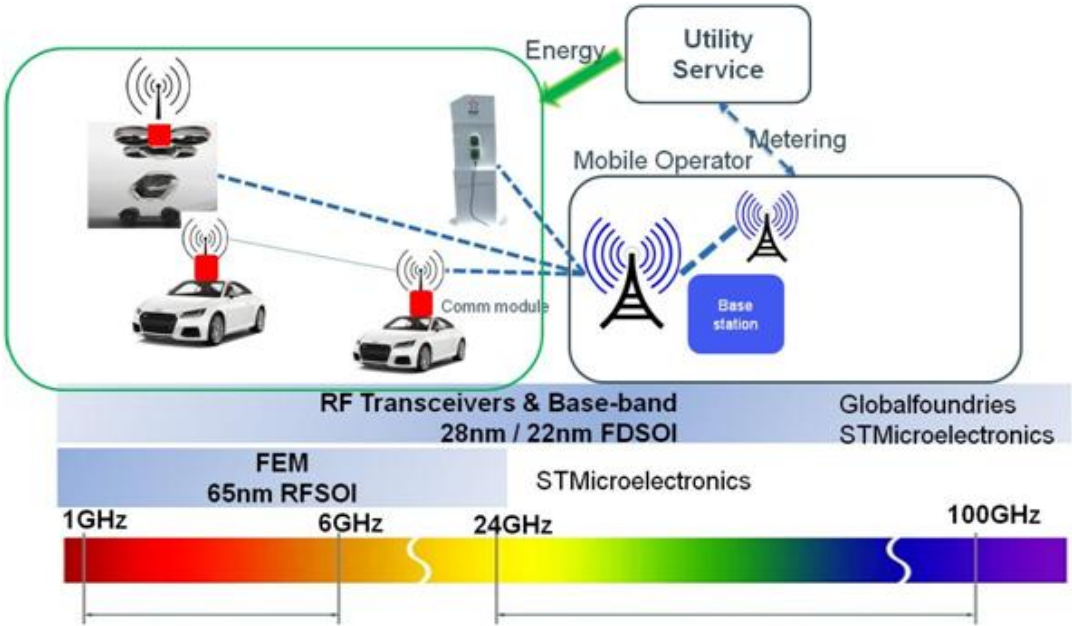
- Industry events for the industry by the industry around the world
  - Sept 2014, Shanghai
  - Jan 2015, Tokyo; Feb 2015, Si Valley; April 2015, Hsinchu, Taiwan; Sept 2015, Shanghai
  - Jan 2016, Tokyo; April 2016, Si Valley; Sept 2016, Shanghai
  - April 2017, Si Valley; Jun 2017, Tokyo; Sept 2017, Shanghai
  - *Mar 2018 Brussels; April 2017, Si Valley; Jun 2018, Tokyo; Sept 2018, Shanghai*
- Topics: foundry platform, design ecosystem and first products
- Contributors: Institutes, Industry, Fabless, Market Analysts, Investment Funds

Ecosystem Partnership: 5G connectivity

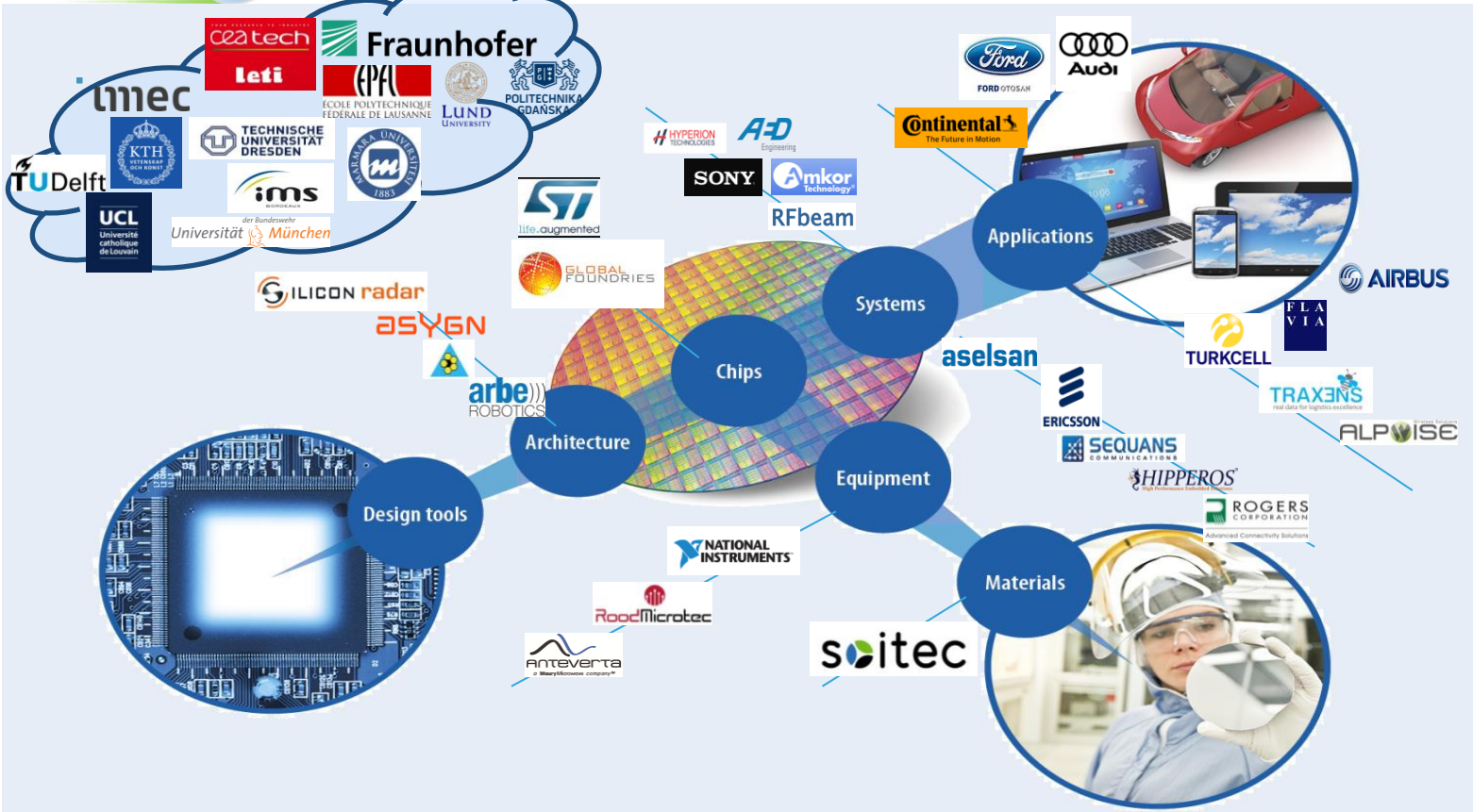
Main challenges and DRIVERS

-Increased linearity and higher number of communication bands and bandwidth
-Robust and **highly integrated RF FEM** with **no performance degradation at high temp**

Driving demand:
-Reliable **cyber-physical communication systems** (**V2X**) for Smart Autonomous Vehicles (**Automotive**, **Aeronautics**)
-Low-latency, available, low-power **Infrastructure** (communication modules & equipments)
-New business models with mobile connectivity for utility providers (**Energy, Smart Metering**)



Ecosystem Partnership: Value Chain



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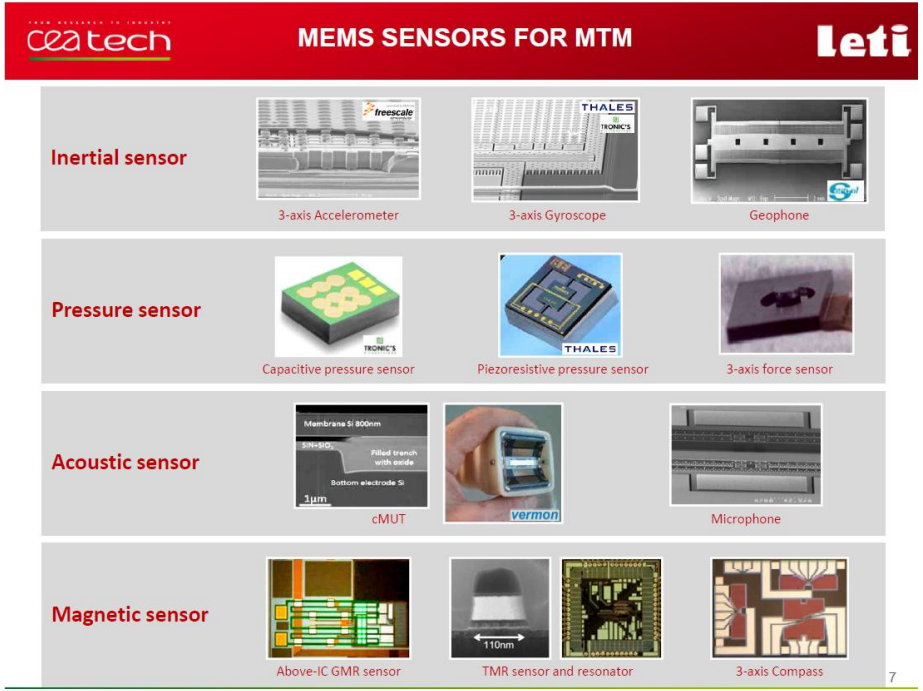
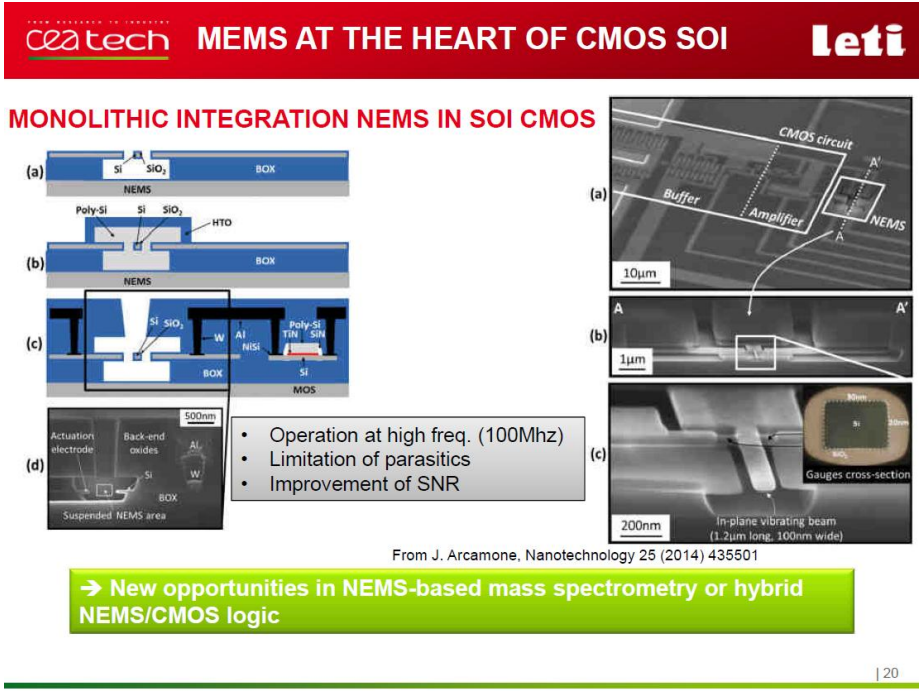
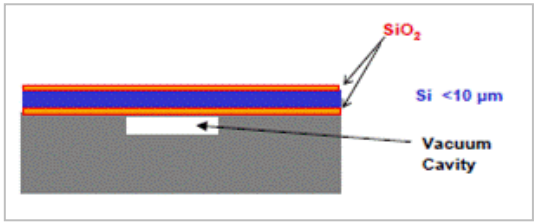
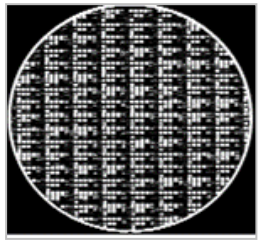
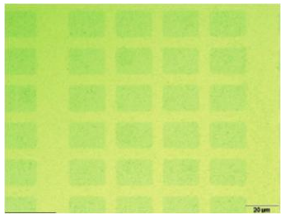
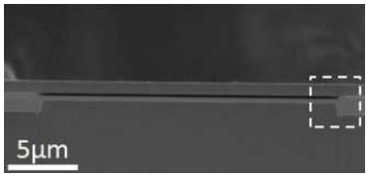
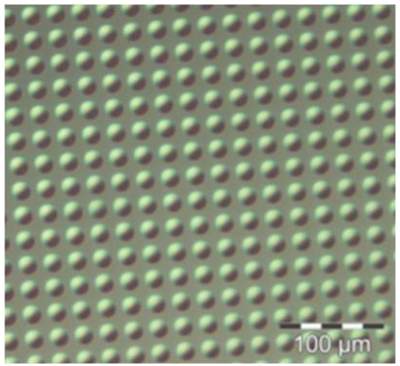
SOI for Sensors – MEMS - NEMS





Source: Presented at Tokyo SOI Workshop, June 2016

SOI for Sensors & Actuators: Layer transfer on cavities

"Thick" 5-10µm	"Thin" ~ 1µm	"Ultra-Thin" ~0.15µm
  25-100-500 µm	  leti cea tech	 OKMETIC

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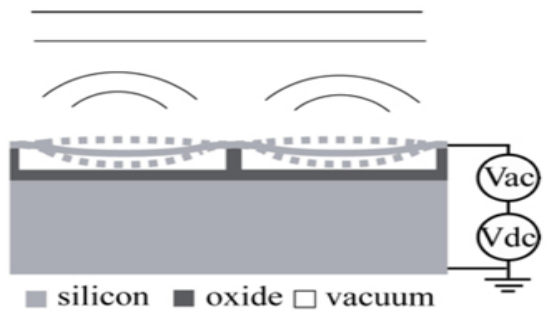
cMUTs & pMUTs

(Micromachined Ultrasonic Transducers)

Capacitive MUTs
cMUTs

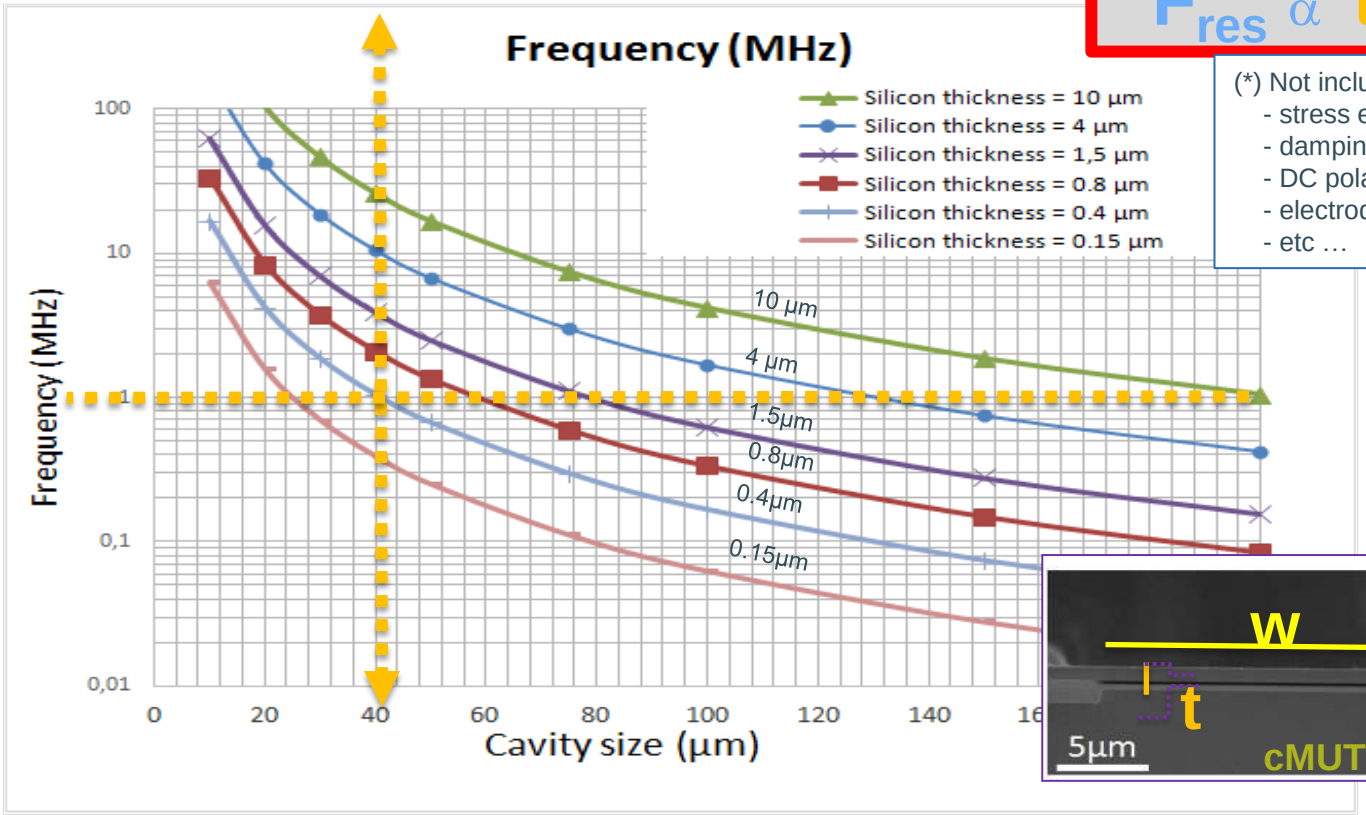


Suspended Membranes

MUT: Resonance Frequency control (very simplified model*)

$F_{res} \alpha t / w^2$

(*) Not including :
- stress effects,
- damping, loading,
- DC polarization
- electrode stack
- etc …



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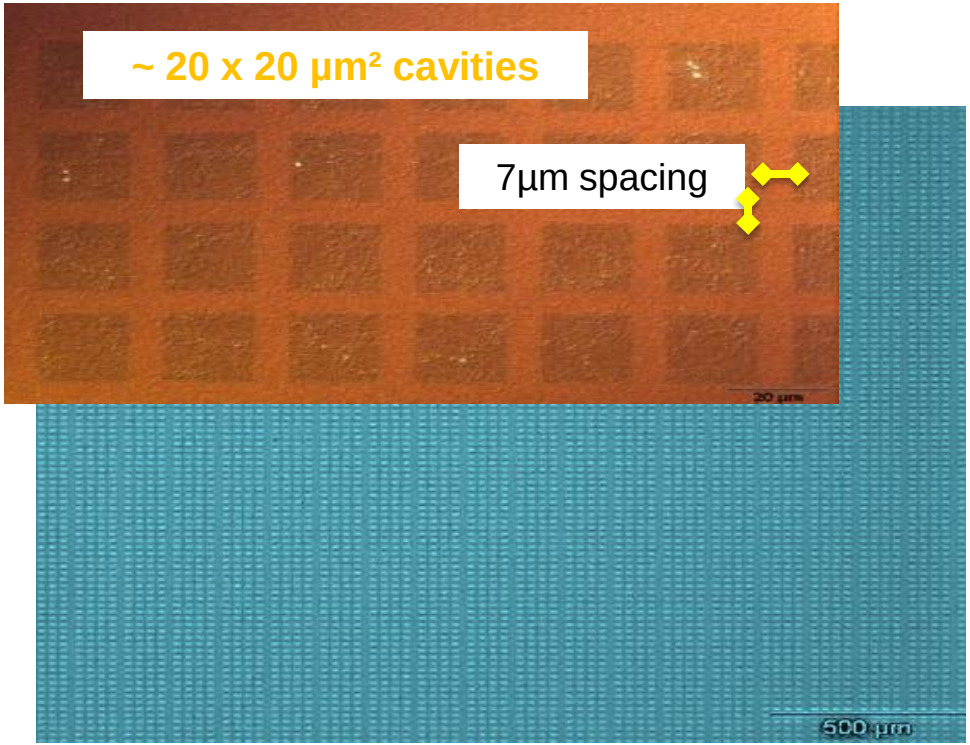
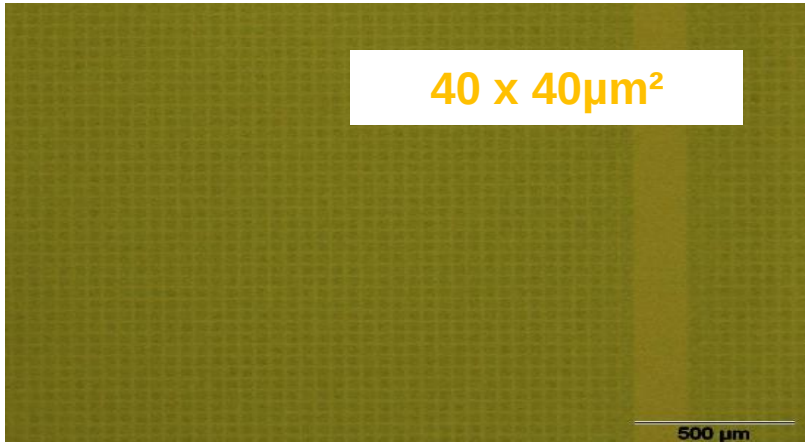
Si membranes on cavities :

- 20x20 µm² and 40x40 µm² cavity arrays

- ~1 µm Si membrane



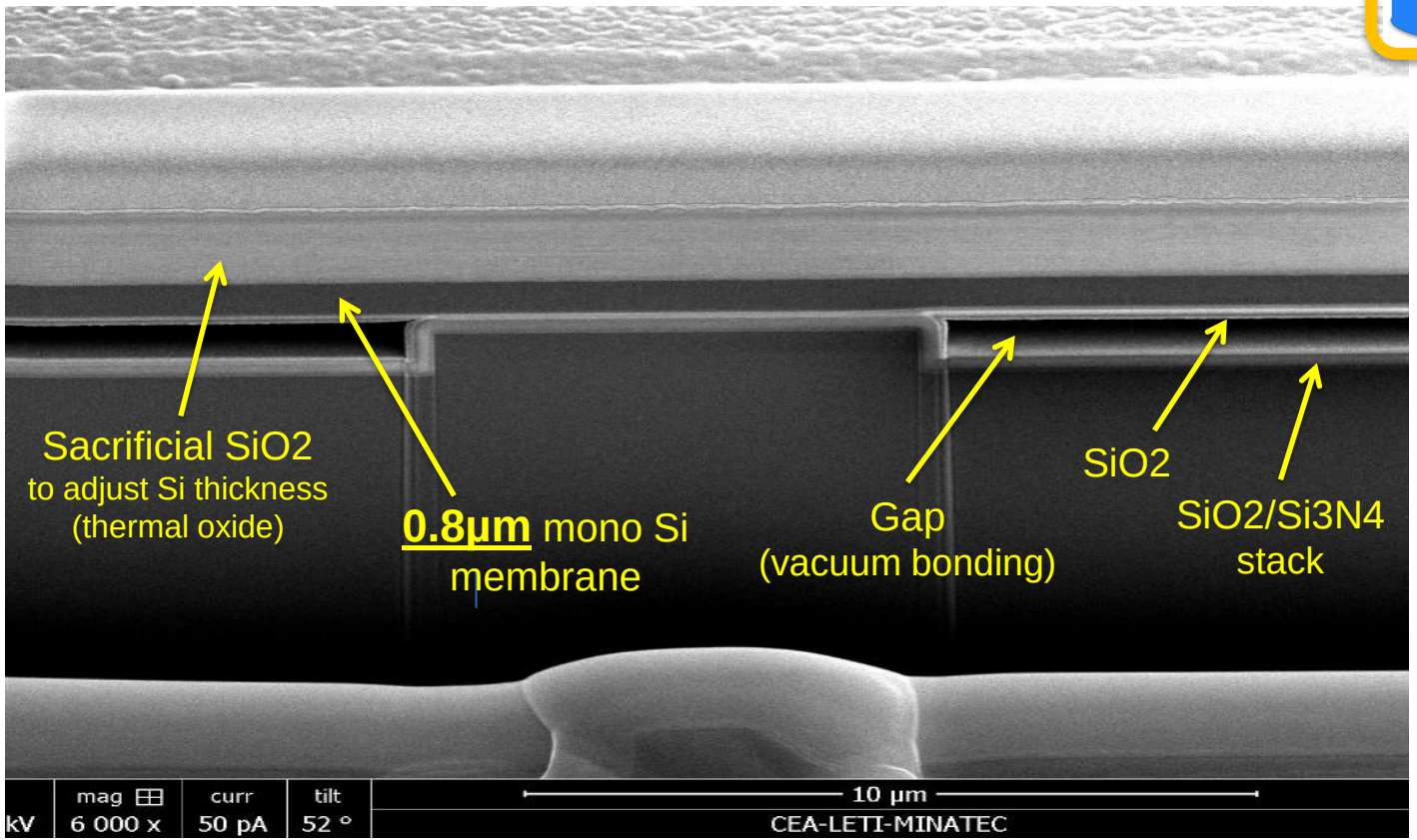


Wafer diameter : 200mm

➔ Very dense arrays become possible !

Collaboration

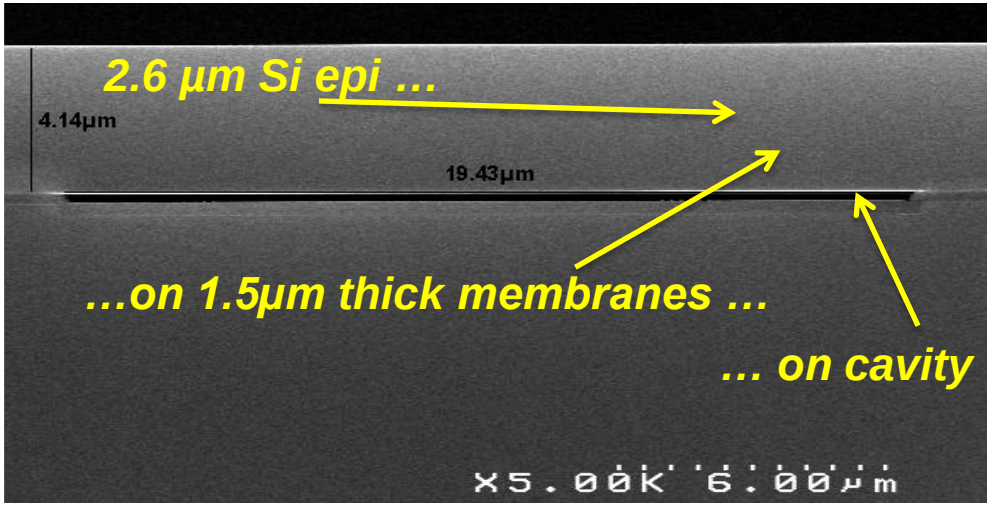
0.8µm thin membranes on 40 x 40µm² arrays



Collaboration

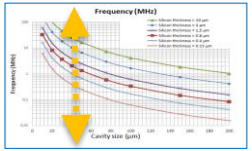
~ 4 µm epi thickened membranes on 20 x 20µm² arrays

Front-end CMOS compatible engineered substrate



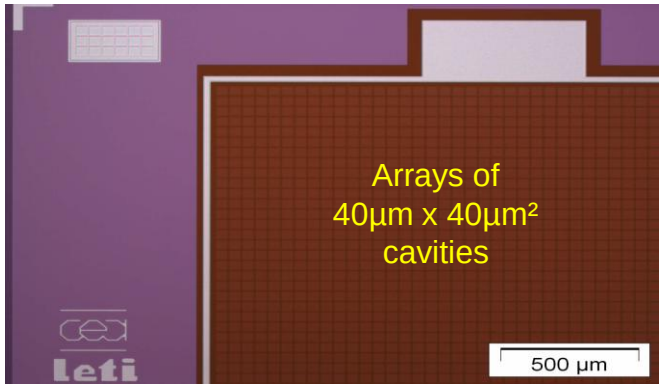
MembraneThickness flexibility

- ➔ **Tuning downwards** by etching, sacrificial oxidation,...
- ➔ **Tuning upwards** by epitaxy (before or after transfer on cavity)

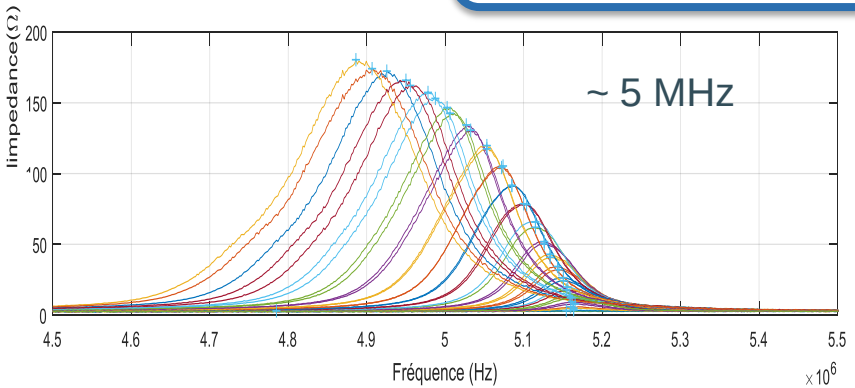


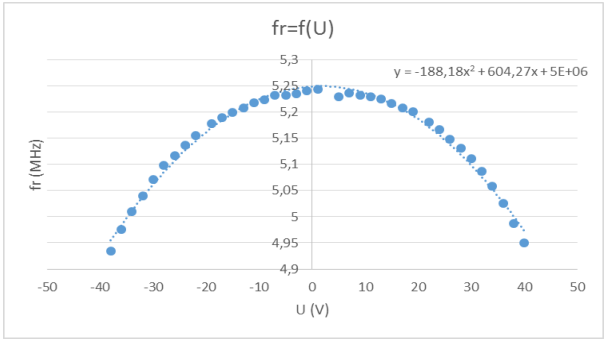
Collaboration

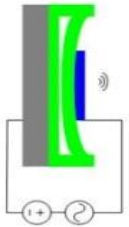
cMUT electrical characterization



Collaboration







More than Moore: Ecosystem growth

2018 Japan SOI Workshop Tokyo, 2018.10.26

Takeda Hall, Tokyo University

Session: Keynotes **Chair: Carlos Mazure, SOI Industry Consortium**

9:40 - 10:10 Distributed AI and computing at edge and nodes for sensors, Giorgio Cesana, Sr. Director, STMicroelectronics

10:10 – 10:40 RF- & FD-SOI: addressing substrate supply to support accelerated growth, Jean-Marc LeMeil, Director, Soitec

10:40 – 11:10 FD-SOI for ultra low power edge computing, Jon Cheek, Director, NXP

Session: MEMS & Sensors **Chair: Jon Cheek, NXP**

11:40 - 12:05 A Time-of-Flight Range Image Sensor with High Near Infrared Quantum Efficiency Using SOI-Based Fully-Depleted-Substrate Detectors; Prof. Shiji Kawahito, Shizuoka University

12:05 – 12:25 An Overview of SOI based MEMS; Jean-Philippe Polizzi, MEMS Business Development Manager, Leti-CEA

12:25 – 12:50 Smart Cut technology applied to MEMS: illustration in the field of ultrasonic transducers; Bruno Ghyselen, Sr. Expert, Soitec

12:50 - 13:50 Lunch

Takeaway: Substrate-Device-Application Co-Optimization

Innovation platforms

Systems

ICs

Materials

Sensing, 5G, Cloud

Flexible IC

Virtual wafers 8" or 12" for small diameter materials: InP, GaN, GaAs, LiTa03, LiNbO3,…

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