SOI substrates - addressing substrate supply to support accelerated growth

Jean-Marc LEMEIL
Product engineering Director, Soitec
Agenda

1. Introduction to Soitec
2. RF-SOI substrates
3. Power-SOI substrates
4. FD-SOI substrates
5. SOI manufacturing and supply
Soitec – A leading engineered substrates supplier addressing large consumer related Markets

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

Key Market players
- Globalfoundries
- TSMC
- UMC
- SMM
- Texas Instruments
- HMC
- Infineon
- Qorvo
- Samsung
- Huawei
- Apple
- Qualcomm
- Sony
- Cisco

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Soitec products well positioned in high growth markets today and tomorrow

2000-2010
PC, Gaming & Automobile
Main Soitec product: PD-SOI

SINCE 2010
Mobile, Automobile & Industry
Main Soitec products: RF-SOI, Power-SOI

2017+
Electronics for Everyday Use
Main Soitec products: FD-SOI, RF-SOI, Power-SOI and other products to come

2020+
5G World

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RF-SOI substrates
RF-SOI is the standard addressing requirements of LTE/4G and 5G

<table>
<thead>
<tr>
<th>Increased complexity to deliver higher data rates</th>
</tr>
</thead>
<tbody>
<tr>
<td>2016 ← 3X higher data rate → 2021</td>
</tr>
<tr>
<td>2X more antennas</td>
</tr>
<tr>
<td>50X more carrier aggregation cases</td>
</tr>
</tbody>
</table>

**Value proposition**

- Enables Integration (switch, LNA, PA, passives)
- Lowest cost vs. GaAs and MEMS technologies
- Available in both 200 and 300mm

**Growing RF-SOI content: migration to new LTE standards**

<table>
<thead>
<tr>
<th>iPhone 5S</th>
<th>iPhone 6</th>
<th>iPhone 7</th>
<th>Samsung Galaxy S8</th>
</tr>
</thead>
<tbody>
<tr>
<td>9mm²</td>
<td>18mm²</td>
<td>27mm²</td>
<td>32mm²</td>
</tr>
</tbody>
</table>

2021 >40mm²

Source: Soitec estimates, Navian April 2017

**RF-SOI TAM (8” equivalent)**

Current addressable market in 2016:

~1M wafers/y.

~15% CAGR

Soitec estimated market by 2021:

>2M wafers/y.

Source: Soitec estimates
FEM market dynamic

- LTE advanced and 5G roll out will continue to drive FEM complexity increase:
  - More bands and bands combinations
  - Larger bands and higher frequency bands
  - Carrier aggregation uplink: double the main path
  - MIMO 4x4
  - More antennas: increase the number of diversity modules

![Increase of bands through LTE A PRO & 5G <6GHz](image)

![RF-SOI average area (mm²) in a front end module](image)

- Expecting >50mm² RF-SOI inside a 5G FEM

Source: Soitec internal
RF-SOI: strong demand and growing at 15% CAGR

- RF-SOI standard technology in FEM
  - Switches, tuners, LNAs

Expecting to break the 2M wafers (200mm equivalent) by 2020.

Source: Soitec internal
Mapping device linearity requirement to the right RF-SOI products
**Soitec RF-SOI wafers: HR-SOI & RFeSI™ substrates**

**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

RFeSI relies on a unique Trap Rich layer limiting high frequency signal propagation in the substrate - boosting device RF performance.

Source: Soitec internal

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3 Power-SOI substrates
Power-SOI

Semi content drivers for automotive and industrial applications

- More electronic content per vehicle
  - IVN network
  - Safety
  - Infotainment

- New energy efficiency standard
  - Next generation of “white goods”
  - Industrial applications

Value proposition

- High reliability
- Automotive grade compatibility proven
- Easy integration of different voltages
- High temperature compatibility
- Low Electro Magnetic Interference (EMI)

Power-SOI content in automotive

Average SOI content in every car

80mm²

2015

>100mm²

2021

Power-SOI TAM (8” equivalent)

~8% CAGR

Soitec estimated market by 2021
>500K wafers /y.

Current addressable market in 2016
350K wafers/y.

Source: Soitec estimates
FD-SOI substrates
FD-SOI brings huge differentiation in mobile, IoT, 5G & automotive markets

<table>
<thead>
<tr>
<th>Mobility</th>
<th>IoT</th>
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<tbody>
<tr>
<td><strong>Best Power/Perf/Cost solution for</strong></td>
<td><strong>Perfect fit for wireless &amp; ULP / ULL IoT clients in need of:</strong></td>
</tr>
<tr>
<td>Low-mid tier <strong>Baseband + AP</strong></td>
<td>On-demand processing performance</td>
</tr>
<tr>
<td>4G transceiver integration</td>
<td>Integrated RF</td>
</tr>
<tr>
<td>5G mmWave design</td>
<td>Embedded memory</td>
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</table>

<table>
<thead>
<tr>
<th>5G &amp; Radars</th>
<th>Automotive</th>
</tr>
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<tbody>
<tr>
<td><strong>Ideal technology</strong> for</td>
<td><strong>Unique advantages in low power/ high reliability (SER)</strong></td>
</tr>
<tr>
<td>5G mmWave low power single chip solution with integrated PA</td>
<td>ADAS (&lt;5W) for autonomous driving</td>
</tr>
<tr>
<td>&lt;6GHz applications (transceivers) w/ 35-50% die shrink (vs 28 poly) for LTE, Wifi and other wireless applications</td>
<td>Radar - Mid to long range single chip</td>
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<tr>
<td></td>
<td>Infotainment</td>
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<tr>
<td></td>
<td>MCU for Body Electronics</td>
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</tbody>
</table>

FD-SOI global wafers estimate: 2021 (est.): 1-3M wafers/y.

Source: Soitec estimates
FD-SOI unique features

**Ultra Low Voltage**
- Operation at minimum energy point (<0.4V)
- Best CMOS mmWave with similar performance to SiGe radios

**mmWave RF-CMOS**
- Up to 6X energy efficiency gains at ULV

**Body Bias**
- 400GHz fMax
- Leakage spread reduction

**Reliability**
- Neutron-SER in FT/Mb
- 20x Soft Error Rate improvement vs. bulk

Source: P. Flatresse, ST, ICICDT17
Source: GF, GTC2017
Source: Sugii, Low Power El. Appl. 2014
Source: ST, Shanghai FDSOI forum, 2015

Source: ST, SOI Industry Consortium, Tokyo

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FD-SOI: the best energy saving CMOS platform

<table>
<thead>
<tr>
<th></th>
<th>Value/Cost</th>
<th>Multi RF integration</th>
<th>Ultra Low Power Energy Efficiency</th>
<th>Reliability</th>
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<tbody>
<tr>
<td>Planar bulk</td>
<td>✔</td>
<td>✔</td>
<td>✗</td>
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<tr>
<td>FinFET</td>
<td>✔</td>
<td>✗</td>
<td>✗</td>
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<tr>
<td>large die</td>
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<tr>
<td>small die</td>
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<td>FD-SOI</td>
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FD-SOI: An ecosystem stronger than ever

<table>
<thead>
<tr>
<th>Research Technology &amp; IP</th>
<th>Substrates</th>
<th>IP &amp; Design Services</th>
<th>Fabless &amp; OEMs</th>
<th>Consumer Products</th>
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<tbody>
<tr>
<td>CEA</td>
<td>Soitec</td>
<td>Delphi</td>
<td>&gt;100 customer engagements</td>
<td>Casio</td>
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<td>Leti</td>
<td>Soitec</td>
<td>Silvaco</td>
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<td>Synopsys</td>
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<td>Cadence</td>
<td></td>
<td>i.MX 7ULP</td>
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<td>GLOBAL FOUNDRIES</td>
<td>Soitec</td>
<td>Cadence</td>
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<td>Cadence</td>
<td></td>
<td>NXP</td>
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Level 3 autonomous driving
EyeQ4
Xperia Ear Duo

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5 SOI manufacturing and supply
Addressing growth and technology requirements in 200-300mm

- 200mm production is strong and will remain strong
  - Majority of current RF & Power products
  - Well established ecosystem
  - Will continue to grow

  Adjust Bernin fab capacity
  Strong partnership with SIMGUI in China

- 300mm is in high volume production and will capture significant part of the growth for advanced nodes
  - FD-SOI technology offer down to 12nm
  - RF-SOI to integrate LNA performances
  - Logic shrink
  - mmW capability

Soitec multi fabs in Bernin & Singapore
Soitec is supporting both 200mm and 300mm growth

200mm SOI
- Soitec Bernin I, France HVM
  - 900K wafers/y capacity with plan to extend to 950K
- Total 200mm capacity → 1.1M wafers/y. by FY’19 (0.5M/y equivalent 300mm)

300mm SOI
- Soitec Bernin II, France HVM
  - 650K wafers/y. capacity with plan to extend to 800K
- Contemplated capacity: 800K wafers/y + EPI capacity
  → Up to 1.6 M wafers/y.

- Simgui, China Ramp to HVM
  - 150K wafers/y. capacity w/ plan to extend to support China & WW market
- Pasir Ris, Singapore Ready HVM
  - 150K wafers/y capacity w/ plan to extend to support China & WW market
- Total potential 300mm capacity

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Singapore fab restart project status

› FACILITIES
  › PR1 Facilities fully restarted since Jan 2018
  › PDSOI Fab upgraded for FDSOI and RFSOI

› FD-SOI
  › Pilot line qualified (Process, metrology & facilities) with state-of-the-art equipment ready to ramp

› RF-SOI
  › Epitaxy Process (for RFeSi wafers) fully qualified and ramping
  › RF-SOI Pilot line being qualified by Dec 18
### Singapore fab project management

<table>
<thead>
<tr>
<th></th>
<th>Q3 CY17</th>
<th>Q4 CY17</th>
<th>Q1 CY18</th>
<th>Q2 CY18</th>
<th>Q3 CY18</th>
<th>Q4 CY18</th>
<th>Q1 CY19</th>
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<td>Dec</td>
<td>Jan</td>
<td>Feb</td>
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<td>Sep</td>
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<tr>
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<td>Dec</td>
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<tr>
<td><strong>Q1 CY18</strong></td>
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<td><strong>Q2 CY18</strong></td>
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<td>Dec</td>
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<td>Mar</td>
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<td>Sep</td>
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<tr>
<td><strong>Q1 CY19</strong></td>
<td>Oct</td>
<td>Nov</td>
<td>Dec</td>
<td>Jan</td>
<td>Feb</td>
<td>Mar</td>
<td>Sep</td>
</tr>
<tr>
<td><strong>BASE RFeSI</strong></td>
<td>1st Sample to customers</td>
<td>Full flow preparation and customer samples</td>
<td>Ramp up to 100kwopy Phase 1</td>
<td>1st Sample to customers</td>
<td>Techno. Transfer package, Pipe Cleaner &amp; Line Qual</td>
<td>Ramp up ready</td>
<td></td>
</tr>
<tr>
<td><strong>RF-SOI</strong></td>
<td>Fac. &amp; Eqp. Partial flow</td>
<td></td>
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<tr>
<td><strong>FD-SOI</strong></td>
<td>Fac. restart &amp; Eqp. install</td>
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**SOI Industry Consortium, Tokyo**

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Securing raw bulk supply

- **Benefits from unique Soitec position to access multi-sources of raw material**
  - LTA signed with major suppliers
  - New suppliers qualification to increase multisourcing (200-300mm)
    - Evaluating new alternative sources potential
  - Collaboration with our HVM suppliers to maximize productivity, performance & flexibility
  - Make or Buy 300mm EPI strategy
    - Secure EPI capacity with major silicon suppliers
    - EPI in-sourcing capacity at SGP fab with Soitec Capex
  - Make or Buy 300mm Donor Refresh wafer strategy
    - Secure Donor wafer capacity with majors Bulk suppliers
    - Refresh in-sourcing capacity in 2 fabs with Soitec Capex

- **No fundamental capacity limit for long term supply**
  - Market must anticipate the growth acceleration
  - Market must plan long term ahead all over the supply chain
## 300mm FD-SOI & RF-SOI – Supply Maturity to support accelerated growth

<table>
<thead>
<tr>
<th></th>
<th>Bulk Multi-sourcing</th>
<th>Supply contracts</th>
<th>Yield Maturity</th>
<th>SOI / EPI capacity</th>
<th>Ready to market growth</th>
</tr>
</thead>
<tbody>
<tr>
<td>FD-SOI</td>
<td>3 sources</td>
<td>✓</td>
<td>✓</td>
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</tr>
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<td>RF-SOI</td>
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<tr>
<td>TR Layer</td>
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<td>✓</td>
<td>✓</td>
<td>✓</td>
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</tbody>
</table>
Closing remarks

› Soitec is continuously bringing differentiation in FEM, IoT, 5G & automotive markets evolution by developing new engineered substrates and by adding new manufacturing capacity directly or through partnership

› RF-SOI demand is strong and growing driven by 4G LTE advanced and upcoming 5G sub 6GHz

› FD-SOI revolution has started with consumer & automotive

› 300mm RF-SOI & FD-SOI will take part of the growth and enabling new technology integration - 5G seen as a strong driver

› RF-SOI & FD-SOI manufacturing fabs adjusted to meet market demand

› Raw wafer supply secured with major bulk suppliers

› Market growth acceleration addressed with long term anticipation
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