Soitec Products enabling RF FEM Performance

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Soitec – Leader in Engineered Substrates

essential to energy efficiency & performance

- ~20% of staff working in R&D
- 350 patent applications / year
- 3,000 active patents

Technologies:
- Smart Cut™
- Smart Stacking™
- Epitaxy Expertise
- Concentrix™

Applications:
- Green Electronics
  - Engineered substrates
  - 2 M wafers /year
- Solar - Clean Energy
  - CPV systems
  - 350 MW /year
- LED - Efficient Lighting
  - High performance GaN substrates
  - Supply Lighting system
<table>
<thead>
<tr>
<th>IoT challenges</th>
<th>Technology challenges</th>
<th>Soitec engineered substrates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ubiquitous Connectivity</td>
<td>Integrate more RF content</td>
<td>✓ Substrate for RF</td>
</tr>
<tr>
<td>Multimedia Apps &amp; OS</td>
<td>x2 transistors every 2 years</td>
<td>✓ Substrate for Digital</td>
</tr>
<tr>
<td>Intuitive Interface</td>
<td>Integrate more analog and power content</td>
<td>✓ Substrate for Power and MEMS</td>
</tr>
<tr>
<td>Pervasive Computing</td>
<td>Access remotely to more data faster</td>
<td>✓ Substrate for Photonics, memories, big data</td>
</tr>
</tbody>
</table>

Soitec addressing Mobile and Internet of Things challenges

- Wireless Communication: 2G 3G LTE, WIFI, BT, NFC
- Digital processing
- Sensors & Power Management
- Cloud computing

30 September 2014
Smart-Phones performance drive RF growth

<10kbps <100kbps ~1Mbps Up to 100Mbps Up to 1Gbps

RF Devices/ Modules Market Forecast For Cellular

$ Million

Source: Navian 2013
Front end module semiconductor area
Equivalent Silicon/SOI content – CAGR above 30%

<table>
<thead>
<tr>
<th></th>
<th>2.5 G smartphone</th>
<th>3G smartphone</th>
<th>LTE smartphone</th>
<th>LTE Adv smartphone</th>
</tr>
</thead>
<tbody>
<tr>
<td>2G  4 bands</td>
<td>2G  4 bands</td>
<td>2G  4 bands</td>
<td>2G  4 bands</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3G  4 bands</td>
<td>3G  6 bands</td>
<td>3G  6 bands</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>LTE 4/12 bands</td>
<td>LTE &gt;15/50 bands</td>
<td></td>
</tr>
<tr>
<td>2 PA &amp; 1 SW</td>
<td>6 PA &amp; 3 SW</td>
<td>System</td>
<td>System</td>
<td></td>
</tr>
<tr>
<td>5 mm²</td>
<td>12 mm²</td>
<td>&gt;24 mm²</td>
<td>&gt;32 mm²</td>
<td></td>
</tr>
</tbody>
</table>

Increasing silicon content for switch and PA: 30% CAGR 2011-2016

Soitec estimates
Front End Module getting more and more complex
Tunable, more linear and efficient devices - Switch and filter are proliferating

RF front-end devices: interaction between skills enable better performance

- **Design**
  - Integrate complex functionalities

- **Process**
  - Tuning of standard process

- **Substrate**
  - Propose “ideal” substrate
  - Substrate a key element to bring the RF performance

- **Fabless**
  - Develop the devices for RF market

- **Foundries**
  - Develop the process based on SOI wafer

- **Soitec**
  - Drives the RF performance with improved substrate

- **R&D**
  - Analyse and provide technological solution (UCL, Leti)

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RF FEM – Key Challenges and Benefits

RF SOI key benefits

**User expectations**
- Higher data rate
- Longer battery life
- Ubiquitous connection

**RF chips requirements**
- Higher integration
- Improved RF isolation
- Enhanced signal integrity

**Soitec RF substrates**
- Wave SOI™: HR-SOI & eSi
- Mainstream technology in handsets
- Top material enabling integration
- Intrinsic isolation
- Built-in resistive base

Soitec RF SOI leadership: from ideas to high volume manufacturing to become mainstream

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RF-SOI is mainstream for switches and antenna tuner: >80% market share

- **RF-SOI enable LTE performance**
  - State of the art Ron.Coff < 120fs
  - Linearity IIP3 > 80dBm

- **RF-SOI cost efficiency:**
  - Single die integration
  - RF-SOI switch solution 2x smaller than GaAs

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**Technology trends for antenna switches in handsets**

Source: Yole Development, Feb 2014

All Major RF Fabless design on SOI only
RF-SOI offers the best path towards all-in-one RF FEM

- Antenna Switches
- Antenna Tuner
- Power Amplifier
- Tunable Filters

SOI > 80% in antenna switch, 2013

Technology trends for antenna switches in handsets

<table>
<thead>
<tr>
<th>Year</th>
<th>MEMS</th>
<th>SOI</th>
<th>SOS</th>
<th>GaAs</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>100%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>2011</td>
<td>80%</td>
<td>15%</td>
<td>5%</td>
<td>0%</td>
</tr>
<tr>
<td>2012</td>
<td>60%</td>
<td>30%</td>
<td>10%</td>
<td>0%</td>
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<tr>
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<td>40%</td>
<td>40%</td>
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<tr>
<td>2014</td>
<td>20%</td>
<td>60%</td>
<td>20%</td>
<td>0%</td>
</tr>
<tr>
<td>2015</td>
<td>0%</td>
<td>80%</td>
<td>15%</td>
<td>5%</td>
</tr>
</tbody>
</table>

1st CMOS PA with the Performance of GaAs

![Graph showing 10% delta in PAE (%) between WCDMA (Voice) and Data Details: Vcc = 3.6V, Freq = 707MHz]

- 100% performance equivalent to GaAs
- 10% delta

Source: Yole Development, Feb 2014

- Most RF Fabless on SOI today

Skyworks' SkyOne™
Peregrine UltraCMOS® Global1
RFMD RF Fusion
Qualcomm RF360

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Product families addressing different process and design requirements

Soitec Stacking for RF

Soitec eSi™ -enhanced Signal Integrity-substrate

Soitec Wave SOI™ HR substrate

Mono-crystal Top Silicon

SiO₂ (BOX)

Trap rich layer

High Resistivity SI Base

Circuit on alternative substrate

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Soitec eSi™ product performance and simpler process

- **Design to cost:**
  - Simpler process
  - Smaller RF devices
    - 83% /GaAs switch*

- **Breakthrough RF performance:**
  - Record Figure of Merit \((R_{ON}\cdot C_{OFF})\)
  - Roadmap with 10dBm improvement per generation to meet future requirements

* Source: Peregrine Semiconductor
Stacking for RF: a path for better RF performance

Material or circuit on SOI

Alternative substrate

Double Layer Transfer based on SOITEC Smart Stacking™ technology

- Flexibility in material combination:
  - Glass, Fused silica, ceramics, ...
Soitec – Simgui Partnership Announcement

Soitec and Simgui announce major partnership to produce 200-mm SOI wafers in China for RF and power semiconductor markets.


• **This partnership:**
  – Answers to 200mm-SOI worldwide demand
  – Establishes strategic position in China with Simgui

• **Simgui will manufacture same performance and quality products as Soitec**
Conclusion

- **RF market going through significant evolution:**
  - Strong smart phone market growth
  - Performance requirement increasing to meet the new standards

- **Substrate is a key element for RF FEM ICs:**
  - Collaboration between Designers, Foundries and Substrates is critical

- **Soitec is bringing the right substrate for this market:**
  - Innovative products
  - Manufacturing capacity to support high volume production
  - Roadmap to address future requirement