Sensors from Infineon Technologies AG

Hacker Johannes
2015-09-27

10th International „Hiroshima“ Symposium on the Development and Application of Semiconductor Tracking Detectors
Agenda

1. About Infineon Technologies AG
2. Capabilities
3. Status
4. Summary, Outlook and Contact
1. About Infineon Technologies AG

2. Capabilities

3. Status

4. Summary, Outlook and Contact
We make life easier, safer and greener – with technology that achieves more, consumes less and is accessible to everyone.

Part of your life.
Part of tomorrow.
Infineon Technologies AG

› Automotive

› Industrial Power Control

› Chip Card & Security

› Power Management & Multimarket
Infineon Technologies AG

› About **35,000 employees worldwide** (as of June 2015)
› Infineon and International Rectifier combined **pro-forma revenue of ~€5,150m** (~$6,950m) in Infineon 2014 fiscal year
› Strong technology portfolio with more than **22,800 patents and patent applications** (as of September 2014)
› **33 R&D locations; 20 manufacturing locations**

*non-audited figures
### Infineon Technologies AG

**Top positions in all major product categories**

#### Automotive semiconductors

Total market in 2014: $27.5bn

<table>
<thead>
<tr>
<th>Company</th>
<th>Market Share</th>
</tr>
</thead>
<tbody>
<tr>
<td>Renesas</td>
<td>12.0%</td>
</tr>
<tr>
<td>Infineon (incl. IRF)</td>
<td>10.5%</td>
</tr>
<tr>
<td>STMicro</td>
<td>7.8%</td>
</tr>
<tr>
<td>Freescale</td>
<td>7.5%</td>
</tr>
<tr>
<td>NXP</td>
<td>6.8%</td>
</tr>
</tbody>
</table>

Automotive semiconductors incl. semiconductor sensors.
Source: Strategy Analytics, April 2015

#### Power semiconductors

Total market in 2014: $16.2bn

<table>
<thead>
<tr>
<th>Company</th>
<th>Market Share</th>
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<tbody>
<tr>
<td>Infineon (incl. IRF)</td>
<td>19.2%</td>
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<tr>
<td>Mitsubishi</td>
<td>7.0%</td>
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<tr>
<td>STMicro</td>
<td>5.9%</td>
</tr>
<tr>
<td>Fairchild</td>
<td>5.7%</td>
</tr>
<tr>
<td>Toshiba</td>
<td>5.4%</td>
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</tbody>
</table>

Discrete power semiconductors and power modules.
Source: IHS Inc., September 2015

#### Smart card ICs

Total market in 2014: $2.63bn

<table>
<thead>
<tr>
<th>Company</th>
<th>Market Share</th>
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</thead>
<tbody>
<tr>
<td>NXP</td>
<td>30.5%</td>
</tr>
<tr>
<td>Infineon</td>
<td>23.9%</td>
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<tr>
<td>Samsung</td>
<td>16.0%</td>
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<tr>
<td>STMicro</td>
<td>15.2%</td>
</tr>
<tr>
<td>SHHIC</td>
<td>6.7%</td>
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</table>

Microcontroller-based smart card ICs.
Source: IHS Inc., July 2015

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Decisive competitive advantage: Quality

**Our aspiration**
- Preferred partner for our customers
- Smooth production and delivery
- We focus on stability and the 100 percent fulfillment of our commitments

**Our path**
- Integrated approach along the entire value chain
- Proactive Quality Management for products and processes

**Our standards**
- International Standards, e.g. TS16949, ISO 9001, IEC 17025
- Specific customer requirements
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Infineon Technologies AG Capabilities

› Broad range of mature technologies available
  – Analog, CMOS, Mixed-signal, Power, MEMS and Sensors
› High energy physics relevant wafer-sizes
  – 6“: full-mask and stepper-lithography available
  – 8“: full-mask and stepper-lithography available
  – 12“: stepper-lithography, full-mask in back-end-of-line
› Processes in house
  – Implant, oven, etch, lithography, epitaxy, grinding, testing, sawing
  – Fab in Villach is thin-wafer center of competence
**Development-process**

- **Two modes:**
  - Integrated device manufacturer (IDM)
    - Customer defines requirements
    - Infineon develops the products
    - Qualification at customer
    - Series production by Infineon
  - Joint development e.g. HEPHY-Vienna, CMS, ATLAS
    - Customer defines requirements
    - Customer designs layout according to provided design-rules
    - Infineon develops production-work route
    - Joint characterization and verification
    - Series production by Infineon
## Projects

<table>
<thead>
<tr>
<th></th>
<th>CMS-Upgrade Strip-Tracker</th>
<th>CMS High Granularity Calorimeter</th>
<th>ATLAS-Upgrade Strip-Tracker</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>6”</strong></td>
<td><img src="image1" alt="2S" /> <img src="image2" alt="PSPS" /></td>
<td><img src="image3" alt="CMS High Granularity Calorimeter" /></td>
<td></td>
</tr>
<tr>
<td><strong>8”</strong></td>
<td><img src="image4" alt="2S Long" /> <img src="image5" alt="2S Short" /> <img src="image6" alt="PSPS" /></td>
<td><img src="image3" alt="CMS High Granularity Calorimeter" /></td>
<td><img src="image7" alt="ATLAS-Upgrade Strip-Tracker" /></td>
</tr>
<tr>
<td><strong>Details</strong></td>
<td>n-in-p, 200 um, AC-coupled</td>
<td>p-in-n, n-in-p, 200/300 um DC-coupled</td>
<td>n-in-p, 200/300um, AC-coupled</td>
</tr>
</tbody>
</table>
Infineon 6” AC-coupled Strip-Sensor, p-in-n

- Sensor STL: ~ 10 cm x 7 cm
- 512 strips á 10 cm x 20 um
- 300 um and 200 um thickness

- Performance: very good

Electron beam

Electrons per area
Infineon 6” AC-coupled Strip-Sensor, p-in-n

- Typical IV and CV curves of STL sensors of batch 1
- Full depletion voltage at approx. 250 V
- Global current @ 300 V between 0.7 uA and 1.5 uA

Measurements by HEPHY/Vienna

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Continuous improvement clearly visible throughout the 4 batches

Formation of the irregular area is understood

Improvements at Infineon: Sawing

Improvements at HEPHY: Optimized sensor design

Histograms of I_strip vs. batches

Measurements by HEPHY/Vienna
Infineon 8” p-in-n, AC-coupled Strip-Sensor

- Wafer for CMS-Upgrade-Strip-Tracker
  - Wafer diameter (8” wafer): 200 mm
  - Forbidden margin 10 mm -> 180 mm usable
  - Resistivity ~ 7 kΩcm, n-on-p float zone, orientation <100>
  - 200 µm physical thickness → Vfd~60V
- Main Sensor
  - Size: 94.183 x 153.4 mm²
  - Strips: 2032, Strip length: 75.6 mm
  - Strip Pitch: 90 µm, P-stop: Atoll
- Split groups for first run:
  - p-stop / p-spray
  - Different implant/p-stop depth
  - Different implant/p-stop concentrations
  - Different R_poly doping
First results of Infineon 8” 2S-long Sensor

- IV on full sensor ~4μA
  @ 100V @ 144 cm²
  thickness: 200 μm

- CV: full depletion of main
  sensor at ~70V as expected

- IV on diodes 5x5 mm²
  mostly stable up to 700V

Measurements by HEPHY/Vienna
First results of Infineon 8” 2S-long Sensor

- Two rows with 1016 strips each - Strip-numbers:
  - I_strip
  - R_poly
- Measurements by HEPHY/Vienna
- No pinholes in 10k strips
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Summary, Outlook and Contact

› Infineon produced 6“ and 8“ AC-coupled strip-sensor-prototypes
› Infineon will continue to develop
  – 6“ and 8“ strip & coarse-pixel-sensors for
  – CMS-Upgrade-Strip-Tracker
  – CMS-Upgrade-High Granularity Calorimeter and
  – ATLAS-Upgrade Strip-Tracker
› Contact
  – Johannes Hacker
  – Tel: +43 (5) 1777 3663, Mobile: +43 (676) 8205 3663
  – Email: johannes.hacker@infineon.com
  – Postal address: Siemensstr. 2, 9500 Villach, Austria/Europe
Part of your life. Part of tomorrow.