Evaluation and Qualification of RadHard Infineon Power MOSFETs
The 25th Microelectronics Workshop (MEWS25)
Agenda

• Initial situation
• Various Activities Improving the Availability of Power MOSFETs
• Development, Evaluation and Qualification Activities at DLR
• Results
• Conclusion
Initial situation

- RadHard Power MOSFETs are needed in almost ever space equipment
- Worldwide only one space qualified U.S. manufacturer of RadHard Power MOSFETs
  - ☹️ Quality problems
  - ☹️ Monopoly situation
  - ☹️ Stringent export regulations (ITAR)
  - 😊 Success of European Space Industry depends on the U.S. supply
- → European activities started several years ago to develop RadHard MOSFETs
Various Activities Improving the Availability of Power MOSFETs

• 2004 CNES started Development, Evaluation and Qualification Activities on ST Microelectronic (France) Power MOSFETs:
  • Listed in ESCC QPL since October 2010
  • Power MOSFET, N-CHANNEL, Type: STRH100N10FSY3
  • $V_{DS,\text{Max}} = 100 \text{ V}$
  • $r_{DS(\text{on})} = 35 \text{ m}\Omega$, ($V_{GS}=12\text{ V}$, $I_D=24\text{ A}$)

• IR Power MOSFETs:
  • Disadvantages (see previous slide)
  • Part IRHNJ57234SE (Jedec:2N7487U3):
    • $V_{DS,\text{Max}} = 250 \text{ V}$
    • $r_{DS(\text{on})} = 400 \text{ m}\Omega$
Development, Evaluation and Qualification Activities at DLR

- 2004 – 2005 Analysis and Simulation of Radiation Damages on Infineon MOSFETs
- 2006 – 2008 Investigation of Necessary Measures to get RadHard Infineon CoolMOS Transistors
- 2008 – 2009 Development of RadHard Infineon PowerMOSFETs
- 2009 – 2012 Evaluation and Qualification of RadHard Infineon PowerMOSFETs

- Power MOSFET, N-CHANNEL, Type: BUY **CS***
  - $V_{DS,\text{Max}} = 250 \text{ V}$
    - $r_{DS(\text{on})} = 130 \text{ m}\Omega$, ($V_{GS}=10\text{V}, I_D=34\text{A}$)
    - $r_{DS(\text{on})} = 30 \text{ m}\Omega$, ($V_{GS}=10\text{V}, I_D=8\text{A}$)
2009 – 2012 Evaluation and Qualification of RadHard Infineon PowerMOSFETs

- Target applications (Easy Drop In):
  - DC/DC converters Buck-Boost, Switch Mode, etc.
  - Motor Controls
  - Switch with low loss
- Best in class RadHard Technology:
  - TID up to 300krad on request
  - SEE up to LET 55@90μm (Xe) and LET38@279μm (Xe)
- Listed in ESCC QPL in August 2012

<table>
<thead>
<tr>
<th>Type</th>
<th>RDSon</th>
<th>IDC</th>
<th>QG</th>
<th>Umax</th>
<th>Package</th>
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</thead>
<tbody>
<tr>
<td>BUY25CS12J-01</td>
<td>100mOhm</td>
<td>12A</td>
<td>42nC</td>
<td>250V</td>
<td>SMD0.5</td>
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<tr>
<td>BUY10CS12J-01</td>
<td>100mOhm</td>
<td>12A</td>
<td>42nC</td>
<td>100V</td>
<td>SMD0.5</td>
</tr>
<tr>
<td>BUY25CS54A-01</td>
<td>25mOhm</td>
<td>54A</td>
<td>180nC</td>
<td>250V</td>
<td>SMD2</td>
</tr>
</tbody>
</table>
Results
TID (Pre- and Post-Irradiation) Tests by Infineon

Sample type BUY25CS12J (SMD05):
- $\text{IDSS}(200V)$
- $\text{IGSS}(\pm 20V)$
- $\text{RDSon}(8A, \text{Ugs}=10V)$
- $\text{VSD}(12.4A)$
- $\text{Vgs(th)}(1mA)$

Sample type BUY25CS54A (SMD2):
- $\text{IDSS}(200V)$
- $\text{IGSS}(\pm 20V)$
- $\text{RDSon}(34A, \text{Ugs}=10V)$
- $\text{VSD}(54A)$
- $\text{Vgs(th)}(1mA)$
Results
TID (Pre- and Post-Irradiation) Tests by Infineon

BUY25CS12J-01 / L5490B / SMD05

[Graphs showing the results of TID (Total Ionizing Dose) tests for Infineon Power MOSFETs, with data points for pre-rad, post-rad 2400Gy, anneal 24h, and anneal 168h.]
Results
TID (Pre- and Post-Irradiation) Tests by Infineon

BUY25CS54A-01 / L5491A / SMD2
Results
TID Tests by NASA

Average $I_{DSS}$ as a function of total accumulated dose (open symbols) and annealing (filled symbols). Standard error bars are smaller than the data point symbols and thus are not shown. Dashed line demarcates datasheet specification for the maximum $I_{DSS}$. 
Results

TID Tests by NASA

Change in average gate threshold voltage as a function of total accumulated dose (open symbols) and annealing (filled symbols). Standard error bars are smaller than the data point symbols and thus are not shown. On-state biased samples exhibited a slight recovery during the overnight dose rate of 26.4 rad(Si)/min between the 125 krad(Si) and 150 krad(Si) total dose steps. Dashed line demarcates datasheet specification for the minimum $V_{GS(th)}$. 
## Results

**SEE Tests by Infineon**

### Table 5-1: GANIL beam characteristics for 129Xe (TRIM based).

<table>
<thead>
<tr>
<th>Run</th>
<th>Setting</th>
<th>Degrader</th>
<th>Air [mm]</th>
<th>LET [MeVcm²/mg]</th>
<th>Range [µm]</th>
</tr>
</thead>
<tbody>
<tr>
<td>GANIL2</td>
<td>Al 500µm</td>
<td>98</td>
<td>55.14</td>
<td>90.03</td>
<td></td>
</tr>
<tr>
<td>GANIL3</td>
<td>A</td>
<td>Al 500µm</td>
<td>93</td>
<td>55.1</td>
<td>90.28</td>
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<tr>
<td>GANIL3</td>
<td>B</td>
<td>Al 300µm</td>
<td>150</td>
<td>38.02</td>
<td>278.9</td>
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</tbody>
</table>
Results
SEE Tests by Infineon

![Graph showing SOA (Safe Operating Area) for the BUY25CS-Family MOSFETs by Infineon. The graph plots drain voltage (V) against gate voltage (V). Two lines are shown: one for LET = 55 MeV·cm²/mg; d = 90 μm, and another for LET = 38 MeV·cm²/mg; d = 279 μm.](chart13.png)
Results
SEE Tests by Infineon / Comparison

Improved Radiation Hardness (SEE)

IFX: $R_{DS_{on}} = 25\text{m}\Omega$
BUY25CS54A

IR: $R_{DS_{on}} = 40\text{m}\Omega$
## Results

### Competitor Analysis

#### BUY25CS12J – SMD05

<table>
<thead>
<tr>
<th></th>
<th>IR R5</th>
<th>IR R6</th>
<th>IR R5</th>
<th>IR R6</th>
<th>Infineon</th>
</tr>
</thead>
<tbody>
<tr>
<td>BVDSS/V @25°C</td>
<td>250</td>
<td>250</td>
<td>200</td>
<td>200</td>
<td>BUY25CS12J</td>
</tr>
<tr>
<td>RDS(on)/m Ohm @25°C</td>
<td>400</td>
<td>210</td>
<td>220</td>
<td>130</td>
<td>130</td>
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<tr>
<td>RDS(on)/m Ohm @125°C</td>
<td>750</td>
<td>462</td>
<td>300</td>
<td></td>
<td></td>
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<tr>
<td>QG/nC</td>
<td>28</td>
<td>40</td>
<td>35</td>
<td>42</td>
<td>42</td>
</tr>
<tr>
<td>RDS(on)<em>QG/Ohm</em>nC</td>
<td>11.2</td>
<td>8.4</td>
<td>7.7</td>
<td>5.46</td>
<td>5.46</td>
</tr>
<tr>
<td>ID/A @25°C</td>
<td>10</td>
<td>12</td>
<td>12</td>
<td>16</td>
<td>12</td>
</tr>
<tr>
<td>IDM/A</td>
<td>40</td>
<td>49.7</td>
<td>48</td>
<td>64</td>
<td>50</td>
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<tr>
<td>PD/W</td>
<td>75</td>
<td>75</td>
<td>75</td>
<td>75</td>
<td>75</td>
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<tr>
<td>SOA current/A @10ms, 80%V</td>
<td>ca. 0.25</td>
<td>ca. 0.22</td>
<td>ca. 0.3</td>
<td>ca. 0.25</td>
<td>ca. 0.25</td>
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<tr>
<td>EAS/mJ</td>
<td>58</td>
<td>56</td>
<td>60</td>
<td>60</td>
<td>60</td>
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#### BUY25CS54A – SMD2

<table>
<thead>
<tr>
<th></th>
<th>IR R5</th>
<th>IR R6</th>
<th>IR R5</th>
<th>IR R6</th>
<th>Infineon</th>
</tr>
</thead>
<tbody>
<tr>
<td>BVDSS/V @25°C</td>
<td>250</td>
<td>250</td>
<td>200</td>
<td>200</td>
<td>BUY25CS54A</td>
</tr>
<tr>
<td>RDS(on)/m Ohm @25°C</td>
<td>60</td>
<td>40</td>
<td>38</td>
<td>28</td>
<td>30</td>
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<tr>
<td>RDS(on)/m Ohm @125°C</td>
<td>126</td>
<td>80</td>
<td>70</td>
<td></td>
<td></td>
</tr>
<tr>
<td>QG/nC</td>
<td>165</td>
<td>220</td>
<td>155</td>
<td>240</td>
<td>180</td>
</tr>
<tr>
<td>RDS(on)<em>QG/Ohm</em>nC</td>
<td>9.9</td>
<td>8.8</td>
<td>5.89</td>
<td>6.72</td>
<td>5.4</td>
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<tr>
<td>ID/A @25°C</td>
<td>45</td>
<td>50</td>
<td>53.3</td>
<td>56</td>
<td>54</td>
</tr>
<tr>
<td>IDM/A</td>
<td>180</td>
<td>200</td>
<td>214</td>
<td>224</td>
<td>214</td>
</tr>
<tr>
<td>PD/W</td>
<td>250</td>
<td>250</td>
<td>250</td>
<td>250</td>
<td>250</td>
</tr>
<tr>
<td>SOA current/A @10ms, 80%V</td>
<td>ca. 0.5</td>
<td>ca. 0.35</td>
<td>ca. 0.7</td>
<td>ca. 0.6</td>
<td>ca. 0.5</td>
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<tr>
<td>EAS/mJ</td>
<td>222</td>
<td>240</td>
<td>380</td>
<td>268</td>
<td>380</td>
</tr>
</tbody>
</table>
Conclusion

• The 250V RadHard Power MOSFETs of Infineon are the first European qualified RH Power-switches in this Voltage range
• They fulfill all requirements concerning radiation hardness
• The components are ITAR free
• The electrical parameters are superior compared to the devices in the market
• They are available as ESCC qualified flight parts
Thank you for your attention!

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