Qualification and Manufacturing processes for High Performance, Space Grade Microprocessors

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E2v Grenoble
e2v Divisions

High Reliability Semiconductor Solutions
- High-Reliability Microprocessors
- Broadband Data Converters
- Hi-Rel ICs, MRAMs
- Assembly & Test Services
- Lifecycle Management

High Performance Imaging Solutions
- Sensors (CMOS, CCD)
- Cameras
- Low-light sensors
- Thermal Imaging
- X-Ray Imaging

RF Power Solutions
- Microwave Modules
- Travelling Wave Tubes
- Industrial Processing Systems
- Satcom Amplifiers
- Klystrons, Magnetrons, Thyratrons

Aerospace, Defence, Instrumentation
Space, Science, Industrial
Defence, Industrial, Medical
E2v High Reliability Semiconductor Solutions

Avionics
- Flight Computers
- Flight Control Systems
- Voice Data Recorders
- Engine Controllers

Defence
- Missile Systems
- Electronic Warfare
- Counter Measures
- Radar Systems

Industrial
- Transportation
- Oil Drilling
- Telecom
- Test & Measurement

Space
- Space Computers
- Satellite Payload
- Data Processing
- Communications
E2v HRS Space Grade Broad Band Data Converters

- ESCC 9000 screening and qualification flows
- On-going QML V and ESCC 9000 certification
- Columned Ceramic Hermetic packaging
- Radiation and test data available

**ADC**

**EV10AS180**
- 10bit 1.5Gsps
- 2.3ns latency
- 2.4GHz bandwidth
- 1.7W power

**DAC**

**EV12DS130**
- 10bit 1.5Gsps
- 1ns latency
- 6GHz bandwidth
- 1.3W power
e2v HRS Space Grade Microprocessors

**Radiation Tolerant Technology**

- 90nm SOI technology with proven radiation tolerance and flight history
- GHz+ class processors bringing high performance computing into Space

**High-Reliability Assembly**

- Specific assembly including leaded Space Grade capacitors
- HiTCE Ceramic BGA package with high thermal expansion coefficient thus eliminating the need for column grid array

**Space Grade Qualified**

- QML Y manufacturing and qualification flows

**Targeting QML Y Certification**

QML Y – DLA Standard to certify ceramic non-hermetic microcircuits for Space applications
MIL-PRF-38535 QML Y

- E2V participates actively to the QML Y working group
- QML Y aims to facilitate the use of high performance semiconductors for Space applications
- QML Y applies to ceramic non-hermetic devices
- QML Y has been included in the latest release of MIL-PRF-38535 (rev K)
- E2V intends to manufacture and qualify high-performance processors according to QML Y
E2V Flip Chip Assembly

- Flip chip production started in 2000 at e2v Grenoble
- Production line has been upgraded in 2005
- More than 100 kp manufactured in industrial & military levels

2013-2016 program, with ESA & French government funding
- Development of flip chip for 65 nm, complex, high pin count, space level devices
- Upgrade of existing production line

Achievements (January 2014)
- Test vehicle design (daisy chain, thermal, electro migration, speed)
- New equipments
  - 300 mm automatic flip chip available
  - Flip chip reflow furnace W05
  - Flux cleaner in progress
  - Plasma cleaner available
  - Automatic dispenser for Thermal Interface Material W05
  - Scanning acoustic microscope available
  - Seam seal equipment available
Flip-Chip technology assembly process

- Wafer Sawing
- Flip-chip
- Underfilling
- Capacitors attachments
- Balls attachments
High-reliability testing
3 decades of partnership with Freescale
Full screening using original test vectors

Specific space screening
QML-Y process
Highest reliability control available
Full traceability
### Screening Process  Space Grade  PC7448

<table>
<thead>
<tr>
<th>No.</th>
<th>Screening steps</th>
<th>Standard Method</th>
<th>Internal procedure</th>
<th>Requirement</th>
<th>Applicable on FM</th>
<th>Applicable on EQM</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Wafer Lot Acceptance <em>(n)</em></td>
<td>MIL-STD-883 TM 5007</td>
<td>SF 325 10210</td>
<td>All diffusion wafer lots</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>2</td>
<td>Wafer Sawing</td>
<td>MIL-STD-883 TM 2010/A</td>
<td>RD21S00080 SQ32506240</td>
<td>100%</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>3</td>
<td>Die visual selection</td>
<td>MIL-STD-883 TM 2010/A</td>
<td>SQ32506240</td>
<td>100%</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>4</td>
<td>Customer or e2v internal inspection</td>
<td>MIL-STD-883 TM 2010/A</td>
<td>SQ32506240</td>
<td>100%</td>
<td>Yes</td>
<td>e2v By sampling</td>
</tr>
<tr>
<td>5</td>
<td>Die attach (Flip chip)</td>
<td>MIL-STD-883 TM 2010/A</td>
<td>RD21S000760 SQ32506240 SQ32506030</td>
<td>100%</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
<td>6</td>
<td>Die Stud pull</td>
<td>MIL-STD-883 TM 2031</td>
<td>FP21S126680</td>
<td>Each Assy lot (3 devices)</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>7</td>
<td>Underfill material dispense &amp; cure</td>
<td>MIL-STD-883 TM 2009</td>
<td>RD21S000770 SQ32506030</td>
<td>100%</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
<td>8</td>
<td>Capacitors attachment</td>
<td>MIL-STD-883 TM 2009</td>
<td>RD21S200307 SQ32506030</td>
<td>100%</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>9</td>
<td>Marking &amp; serialization</td>
<td>MIL-PRF-38535</td>
<td>RD21S00200 / per device spec.</td>
<td>100%</td>
<td>Yes</td>
<td>Marking only</td>
</tr>
<tr>
<td>10</td>
<td>Xray inspection</td>
<td>MIL-STD-883 TM 2012</td>
<td>SQ325145460</td>
<td>100%</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
<td>11</td>
<td>Temperature Cycling</td>
<td>MIL-STD-883 TM1010 / C / 10 cycles</td>
<td>RD21S00320</td>
<td>100%</td>
<td>Yes</td>
<td>No</td>
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<tr>
<td>12</td>
<td>CSAM</td>
<td>Mil-STD-883 TM 2030</td>
<td>Internal criteria are based on J-STD-020D</td>
<td>100%</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>
### Screening Process  Space Grade PC7448

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
<th>MIL/PRF-38535</th>
<th>Specification</th>
<th>Requirement</th>
<th>Test Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>13</td>
<td>Pre-Burn-In Electricals</td>
<td>MIL-PRF-38535</td>
<td>RD265200868</td>
<td>Per device</td>
<td>100%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>specification</td>
<td>specification</td>
<td>Yes</td>
</tr>
<tr>
<td>14</td>
<td>Dynamic burn-in test</td>
<td>MIL-STD-883 TM 1015 Tc = 125°C 240 hours Conditions see TABLE 4</td>
<td>RD265200868 / Per device specification</td>
<td>100%</td>
<td>Yes</td>
</tr>
<tr>
<td>15</td>
<td>Post-Burn-In Electricals</td>
<td>MIL-PRF-38535</td>
<td>RD265200868</td>
<td>Per device</td>
<td>100%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>specification</td>
<td>specification</td>
<td>Yes</td>
</tr>
<tr>
<td>16</td>
<td>Drift calculation</td>
<td>MIL-PRF-38535</td>
<td>As per Device Specification</td>
<td>100%</td>
<td>Yes</td>
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<tr>
<td>17</td>
<td>Solder ball attach</td>
<td>MIL-STD-883 TM 2009</td>
<td>RD215203654 / SQ32SD06030</td>
<td>100%</td>
<td>Yes</td>
</tr>
<tr>
<td>18</td>
<td>Extreme temp. Electrical</td>
<td>MIL-PRF-38535</td>
<td>RD265200868 / Per device specification</td>
<td>100%</td>
<td>Yes</td>
</tr>
<tr>
<td>19</td>
<td>PDA &lt; 5 percenters</td>
<td>MIL-PRF-38535</td>
<td>Per device specification</td>
<td>All lots</td>
<td>Yes</td>
</tr>
<tr>
<td>20</td>
<td>Physical dimension control</td>
<td>MIL-PRF-38535</td>
<td>RD 215 00630 / per Device Specification</td>
<td>100%</td>
<td>Yes</td>
</tr>
<tr>
<td>21</td>
<td>External Visual</td>
<td>MIL-STD-883 TM 2009</td>
<td>SQ32SD06030 / per device specification</td>
<td>100%</td>
<td>Yes</td>
</tr>
<tr>
<td>22</td>
<td>Customer or e2v final inspection</td>
<td>MIL-STD-883 TM 2009</td>
<td>SQ32SD06030</td>
<td>All lots</td>
<td>Yes</td>
</tr>
<tr>
<td>23</td>
<td>Packing</td>
<td>MIL-PRF-38535</td>
<td>SG215204473 / Per device specification</td>
<td>All lots</td>
<td>Yes</td>
</tr>
<tr>
<td>24</td>
<td>Certificate of Compliance</td>
<td>MIL-PRF-38535</td>
<td>SQ 32S 103660</td>
<td>All lots</td>
<td>Yes</td>
</tr>
</tbody>
</table>
## QCI Space Grade PC7448

### Lot Acceptance Tests

<table>
<thead>
<tr>
<th>Test</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solderability</td>
<td>Mil-STD-883 <em>Internal procedure</em></td>
</tr>
<tr>
<td>Flip chip pull test</td>
<td>MIL-STD-883 <em>TM 2031</em></td>
</tr>
<tr>
<td>Resistance to solvents</td>
<td>MIL-STD-883 <em>TM 2015</em></td>
</tr>
<tr>
<td>Outgassing test on Underfill</td>
<td>ESA-ECSS-Q-ST-70-02C</td>
</tr>
</tbody>
</table>
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### Lot Acceptance Tests

<table>
<thead>
<tr>
<th>Test</th>
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<tbody>
<tr>
<td>Capas chip shear test</td>
<td>Mil-STD-883&lt;br&gt;TM 2019</td>
</tr>
<tr>
<td>Ball shear test</td>
<td>JESD22-B117&lt;br&gt;45 balls</td>
</tr>
<tr>
<td>Temperature cycling</td>
<td>Mil-STD-883&lt;br&gt;TM 1010 cond C 100 cycles</td>
</tr>
<tr>
<td>100 % electrical test</td>
<td>Mil-PRF-38535&lt;br&gt;25°C,-55°C,+125°C&lt;br&gt;(per device specification)</td>
</tr>
<tr>
<td>Flip chip pull test</td>
<td>MIL-STD-883&lt;br&gt;TM 2031</td>
</tr>
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<tr>
<td><strong>Preconditioning</strong> MSL 3 245°C</td>
<td><strong>JEDEC J-STD-020D</strong></td>
</tr>
<tr>
<td>CSAM analysis T0; T1</td>
<td>30°C, 60% RH 192 hours</td>
</tr>
<tr>
<td>Electrical test 25°C; -55°C; +125°C</td>
<td>3 X reflow 245°C</td>
</tr>
<tr>
<td></td>
<td><strong>J-STD-020D criteria</strong></td>
</tr>
<tr>
<td></td>
<td>per device specification</td>
</tr>
<tr>
<td><strong>Temperature cycling</strong></td>
<td><strong>Mil-Std-883 TM1010</strong></td>
</tr>
<tr>
<td>Electrical test 25°C; -55°C; +125°C</td>
<td><strong>Cond C (-65°C/+150°C) 1000 cycles</strong></td>
</tr>
<tr>
<td></td>
<td>per device specification</td>
</tr>
<tr>
<td><strong>Visual Inspection</strong></td>
<td><strong>Internal Specification(2) are based on</strong></td>
</tr>
<tr>
<td></td>
<td><strong>MIL-STD-883 &amp; JEDEC specification</strong></td>
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<td>3 X reflow 245°C</td>
</tr>
<tr>
<td></td>
<td>J-STD-020D criteria per device specification</td>
</tr>
<tr>
<td>Visual Inspection</td>
<td>Internal Specification(2) are based on MIL-STD-883 &amp; JEDEC specification</td>
</tr>
<tr>
<td>THB 500 hours (2)</td>
<td>JESD22-A101</td>
</tr>
<tr>
<td><em>Electrical test 25°C</em></td>
<td>85°C/85% RH; 7.12 psia Continuous bias per device specification</td>
</tr>
<tr>
<td>THB 500 to 1000 hours (2)</td>
<td>JESD22-A101</td>
</tr>
<tr>
<td><em>Electrical test 25°C</em></td>
<td>85°C/85% RH; 7.12 psia Cyclical bias (1 hour ON/1 hour OFF) per device specification</td>
</tr>
<tr>
<td>THB 1000 to 1500 hours (2)</td>
<td>JESD22-A101</td>
</tr>
<tr>
<td><em>Electrical test 25°C</em></td>
<td>85°C/85% RH; 7.12 psia Cyclical bias (1 hour ON/1 hour OFF) per device specification</td>
</tr>
<tr>
<td>Test</td>
<td>Condition</td>
</tr>
<tr>
<td>----------------------------------</td>
<td>------------------------------------------------</td>
</tr>
</tbody>
</table>
| Mechanical shocks                | MIL-STD-883  
  * TM 2002 Cond B                |
| Vibrations                       | MIL-STD-883  
  * TM 2007 Cond A                |
| *Electrical test 25°C;-55°C;+125°C | * per device specification                  |
| Visual Inspection                | SQ 32S 06030 (1)                             |
| Dimensional inspection           | * per device specification                  |
PC7448 Space Grade MPU

PowerPC e600 core
600-1267 MHz operating frequency
Featuring AltiVec SIMD Engine
Up to 5GFlop performance

Embedded Cache:
L1: 32KB I/D, L2: 1MB with ECC

Power Management:
8.4W typical at 1267MHz
Dynamic Frequency Switching (DFS) mode for low-power operation at 600MHz: down to 7.6W at 125°C Nap and Sleep modes, low stand-by power

Radiation tolerant 90nm SOI technology

25×25 mm 360-pin HiTCE Flip-Chip CBGA

Full lead assembly (Solder spheres + capacitors)
PC8548 Space Grade MPU

**PC8548**

*High performance, Low power System-on-Chip for Space*

**Power Characteristics**
- 5.4W typical @ 1200MHz
- 4.6W typical @ 800MHz
- 11.9W max @ 125°C

**On-Chip Security**
- Security Engine
- Optional: Encryption

**High-End Connectivity**
- Dual 32-bit PCI or 64-bit PCI-X
- 4-bit Serial RapidIO
- 4 or 8-bit PCI Express
- Local bus IO interfaces
- 4 GbE interfaces

**PowerPC e500 core**
- 800MHz to 1200MHz
- Integrated L1/L2 Cache
- Double-precision FPU

**Memory Controller**
- 64-bit DDR/DDR2
- Up to 533 MHz data rate
- Error Correction Code
Space Grade Processors Applications

When Satellite Communication is the only option. Unlimited demand for internet everywhere, at sea, in the sky. Fleet management, Remote medical Assistance, online fish sale... e2v enables more Gbps to more users, uninterrupted, everywhere.
ASIC Replacement or General Purpose Microcontroller

Digital Processing Unit

Reduction in Development Time
Reduction in Cost
Use of standard software tools
Telecoms Payloads

L-Band input
ADC
10bit 1.5G
BW=2.4GHz

Digital Processing Unit

L-Band output
DAC
12bit 3G
BW=6GHz

Receiver
RF pre-amp.
Filtering
Down-converter (optional)

Transmitter
RF power amp.
Filtering
Up-converter (optional)
Possible Application as Earth Observation Satellite Computer

Digital Processing Unit

Image from Metsat 10

Image from Metop B
Thank you!