Radiation-Hardened Solutions for CubeSats

Ross Bannatyne, VORAGO Technologies
rbannatyne@voragotech.com
**VORAGO Technologies**

- Privately held fabless semiconductor company headquartered in Austin, TX
- Patented HARDSIL® foundation technology
- Focused on space technology since 2004. Commercializing technology since 2015

**HARDSIL® - Technology**

- Patented semiconductor technology (13 patents to date)
- Licensed to LSI, TI and Global Foundries
- Embedded into standard CMOS manufacturing process
  - Standard manufacturing equipment
  - Fully design agnostic
  - Enhances EOS/ESD performance
  - Eliminates latch-up
  - Improves noise floor immunity
  - Enables high temperature performance beyond 200°C
- Hardens silicon against radiation, temperature and electrical stress

**HARDSIL® - Products**

- Radiation hardened portfolio up to 300k RAD
  - 8M & 16M SRAMs
  - ARM® Cortex®-M0 MCU
- High temperature portfolio 200°C
  - ARM® Cortex®-M0 MCU
HARDSIL® creates a highly conductive layer underneath the CMOS devices and wells combined with a high conductivity connection to well contacts.
How does the VA10820 deal with Single Event Upsets?

SEU – Memory

- EDAC (detect 2 correct 1 bit, per byte)
- Scrub Engine – programmable rate, prevents accumulated uncorrectable errors
- Layout designed to space logically adjacent bits apart
- SER – EDAC enabled – 1e-15 errors / bit-day*
- HARDSIL reduces SEEs

SEU – Logic

- DICE latches
- TMR registers
- Clock glitch filters

* At geosynchronous solar min. with 100 mils of aluminum shielding
VA10820
Radiation-hardened ARM® Cortex®-M0 Microcontroller

Key Features and Advantages
- Latch up Immune with HARDSIL® Hardened by Process Technology
- Power Gating and Hardware Debugger
- 32KB Data and 128KB Program Memory
- 1Kb One Time Programmable Configuration Memory (OTP)
- 24 Counter/Timers with Extensive Hardware/Software Triggering
- 3 SPI (one SPI is master only), 2 I²C, and 2 UART External Interfaces
- 56 Multiplexed General Purpose 3.3V I/O (GPIO)

Specifications
- Total Ionizing Dose (TID) – 300K rad(Si)
- Soft Error Rate (SER) with EDAC disabled – 1.3e-7 errors/bit-day
- Soft Error Rate (SER) with EDAC enabled – 1e-15 errors/bit-day
- Linear Energy Transfer (LET) – 110 MeV-cm²/mg (at T=125°C)
MCU SOLUTIONS ROADMAP  (Memory devices not shown)
RH Embedded Processing System-In-Package

- 68-pin ceramic package
- VORAGO VA10820 MCU
- RH Aeroflex 16-Ch ADC
- Cypress FRAM
- Qualification MIL-PRF-38534 Class K
CubeSat Avionics Reference Design

- Based on Pumpkin CubeSat Kit Bus
- Board available from Pumpkin
- FDK support from Bright Ascension
- Design files available from VORAGO Technologies
  - Modify original design as required (COTS v RH)
Two Common Use-Cases for VORAGO VA10820 in CubeSats

- **Standalone OBC**
  - Main system controller

- **System Monitor / Watchdog**
  - Monitor FPGA and other subsystems
  - Configuration of FPGA
Huge ecosystem of development tools

All popular ARM compilers support VORAGO

Board Support Package available

Application notes available

<table>
<thead>
<tr>
<th>Supplier</th>
<th>Software Development Kit</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ARM Keil</strong></td>
<td><strong>MDK Microcontroller Development Kit</strong></td>
</tr>
<tr>
<td><strong>IAR Systems</strong></td>
<td><strong>IAR Embedded Workbench</strong></td>
</tr>
<tr>
<td><strong>iSYSTEM</strong></td>
<td><strong>winIDEA</strong></td>
</tr>
<tr>
<td><strong>FreeRTOS</strong></td>
<td><strong>Real-time Operating System</strong></td>
</tr>
</tbody>
</table>
VORAGO TECHNOLOGIES

Opening up new possibilities