Ridgetop Semiconductor

Sentinel Network™

RadCell Fox™ Prognostic Cell

FEATURES AND BENEFITS

- **The Ridgetop RadCell Fox Prognostic Cell acts as an early-warning sentinel of an upcoming leakage failure condition caused by radiation exposure**
- **Size: 800 µm^2 at the 0.25 micron process size**
- **Available for 0.35, 0.25, and 0.18 micron CMOS processes**
- **Power dissipation is approximately 50 µW**
- **Prognostic distance can be adjusted from the nominal 80% point**
- **Simple buffered logic high or low output indicates an impending failure event**
- **Optional IEEE-1149.1 JTAG Bus interface**

DESCRIPTION

Total dose radiation exposure results in charged defect densities in the isolation and gate oxide regions of a MOS transistor. The charged defects degrade device performance by introducing changes in threshold leakage current and voltage. The magnitude of the parametric shift is dependent on operating conditions and environment. The Ridgetop RadCell Fox prognostic cell (Figure 1) accurately senses the radiation-induced leakage current in CMOS transistors and outputs the cumulative degradation result.

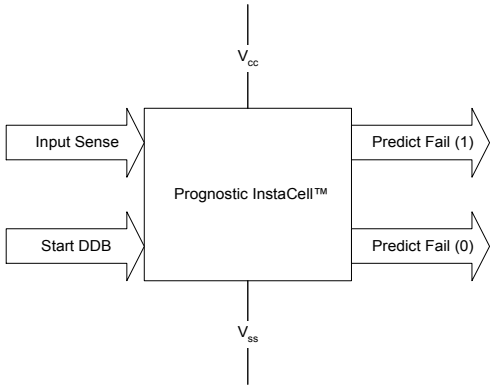

Figure 1: Prognostic Cell Block Diagram

The output is derived from a family of sensor cells, designed and calibrated to trigger at specific values of leakage current. The RadCell Fox prognostic cells reside on-chip with the host application, and are implemented using the device types and geometries available in the target process. This allows the prognostic cell to identically replicate the transistors used in the host application, and makes the output useful in determining the effects of environmental stress on the application's performance and service life.

RadCell Fox prognostic cells can be used as a diagnostic tool, relating device-level parametric shifts to circuit-level performance, or to allow comparison of laboratory test results with field performance. The output of the prognostic cell can also be used as the input for an adaptive-bias control circuit. Multiple cells can be combined with calibrated prognostic distances to accurately track cumulative degradation, consistent with the requirements for condition-based maintenance.

Prognostic Distance

The prognostic distance is the time between the prognostic cell warning point and the time of system failure, as shown in Figure 2. The prognostic distance of the RadCell Fox prognostic cell can be adjusted to meet customer needs by trigger point calibration.

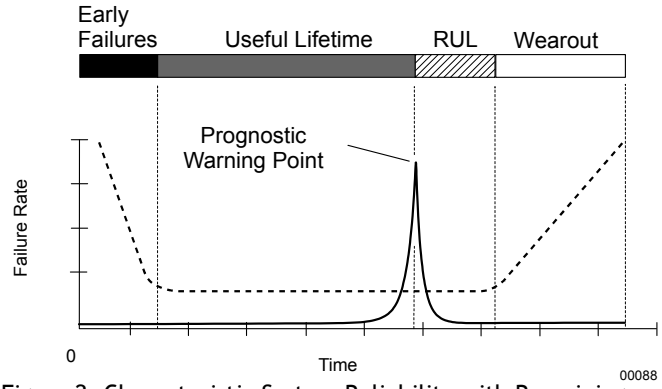

Figure 2: Characteristic System Reliability with Remaining Useful Life (RUL) Indicating Prognostic Distance

RadCell Fox Leakage Cells Test Results

Pre-rad leakage values were low with none of the cells tripped.

Table **1** shows the test results of the RadCell Fox leakage cells during radiation exposure; the cells triggered as designed. These results were as expected, based on the per-edge leakage observed in the stand-alone two-edged n-channel devices with the gate at VDD during irradiation.

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As the radiation exposure levels were increased, the leakage increased and the cells detected this leakage and triggered the appropriate output bit sequence.

Dose rate: Approximately 4.917 rad/s (SiO2).

Dose levels: 25 krad, 35 krad, 45 krad, 60 krad, 75 krad.

Table 1: Simulated Trip Points for RadCell Fox Cells

nA = nanoAmperes; µA = microAmperes

RadCell Fox Cell	Simulated Trip Points
0.1 nA	5.43 nA
1 nA	48.61 nA
10 nA	41.05 nA
100 nA	200.60 nA
1 µA	2.00 µA

The outputs of the RadCell Fox prognostic cells for each dose level are shown in Table 2.

Table 2: Outputs of RadCell Fox Prognostic Cells

	nA				
	0.1	**1**	**10**	**100**	**1000**
Dose (rad(SiO2))	#1	#2	#3	#4	#5
Pre-Rad	0	0	0	0	0
25k	1	1	1	0	0
35k	1	1	1	1	0
45k	1	1	1	1	1
60k	1	1	1	1	1
75k	1	1	1	1	1

Note: Pre-rad value of RadCell Fox cell was 0. The 1 shows that it tripped properly.

Interfacing

The standard RadCell Fox prognostic cell is configured for simple buffered logic high or low output.

Optional Interfacing using the JTAG Bus Structure

Using the JTAG Toolkit, it is also possible to include a register in a chip design that permits an interface using the standard scan test bus that employs IEEE-1149.1. This interface uses four control lines:

TDI - Test Data In
TDO - Test Data Out
TCK - Test Clock
TMS - Test Mode Select

If the JTAG Toolkit is utilized, the prognostic cell uses the TDO and TMS lines. The TDO changes its logic state upon a detected failure event, and the TMS is used to invoke a "self-test" function to ensure that the cell is functional.