RGNBTI

PRODUCT BRIEF

Ridgetop Group Inc

ENGINEERING INNOVATION

Electronic Prognostics

NBTI Prognostic Cell

Industry-Standard, High-Performance, Electronic Prognostic Technology

- Early-warning sentinel of an upcoming threshold voltage failure condition caused by NBTI degradation mechanisms
- Size: 250 µm x 250 µm at 0.13 µm process
- Instantiated in 130 nm CMOS; can be targeted toward any deep submicron CMOS technology
- Power dissipation of approx. 200 microwatts
- Prognostic distance adjustable from nominal 80% point
- Simple buffered logic high or low output indicates impending failure event
- Pipeline architecture
- 4-bit variable gain

General Description

Negative Bias Temperature Instability (NBTI) is an effect that causes a gradual shift in transistor threshold voltage (V_T). It manifests as an absolute drain current IDsat decrease, transconductance (gm) decrease, and absolute threshold voltage increase. NBTI is primarily observed in p-channel MOSFETs when the gate-to-source voltage is negative.

NBTI is caused by charged defect densities in the gate oxide interface region. The V_T shift is dependent on voltage stress on the gate terminal, the temperature, and the duty cycle of the stressing voltage. Typical stress levels required to induce NBTI are temperatures in the 100 to 250 °C range and electric field conditions across the oxide region higher than 6 MV/cm.

The effects of NBTI are of increasing concern as device sizes move to 130 nm and smaller, and operating voltages decrease. As shown in Figure 1, the percent of remaining useful life can be determined with trigger points for the stress voltage, frequency, and duty cycle between the stress and measure cycles.

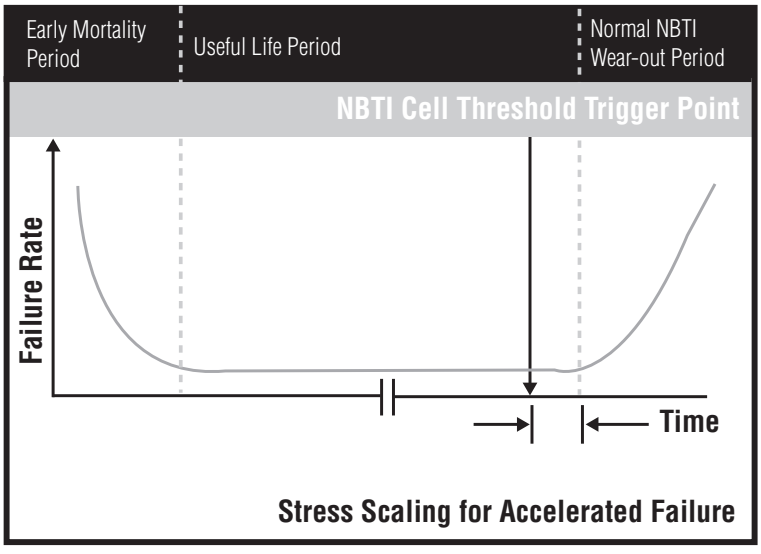

Figure 1: System reliability bathtub curve

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The Ridgetop NBTI Prognostic Cell is derived from the proven RadCell V_T Prognostic Cell, which accurately senses shifts in the CMOS transistor threshold voltage caused by interface traps, and outputs the cumulative degradation result. Output comes from a family of sensor cells, calibrated to trigger at specific values of threshold voltage shifts. The NBTI 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 combined effects of NBTI and environmental stress on the application's performance and service life.

NBTI prognostic cells can be used as a diagnostic tool, relating device-level parametric shifts to circuit-level performance. The output of the cell can also be used as the input for an adaptive-bias control circuit, and multiple cells can be combined with calibrated prognostic distances to accurately track cumulative degradation, consistent with the requirements for condition-based maintenance.

Interfacing

The Ridgetop NBTI Prognostic Cell uses a p-channel diff-amp to measure an increase in the V_T caused by a negative stress voltage on one of the diff-amp inputs. The stress voltage, duty cycle, and frequency can be adjusted for desired operating condition. The cell will operate between the stress mode and the measured mode.

Figure 2 shows a block diagram of the NBTI Prognostic Cell, with Ridgetop's PHMPro® software used for prognostic data acquisition.

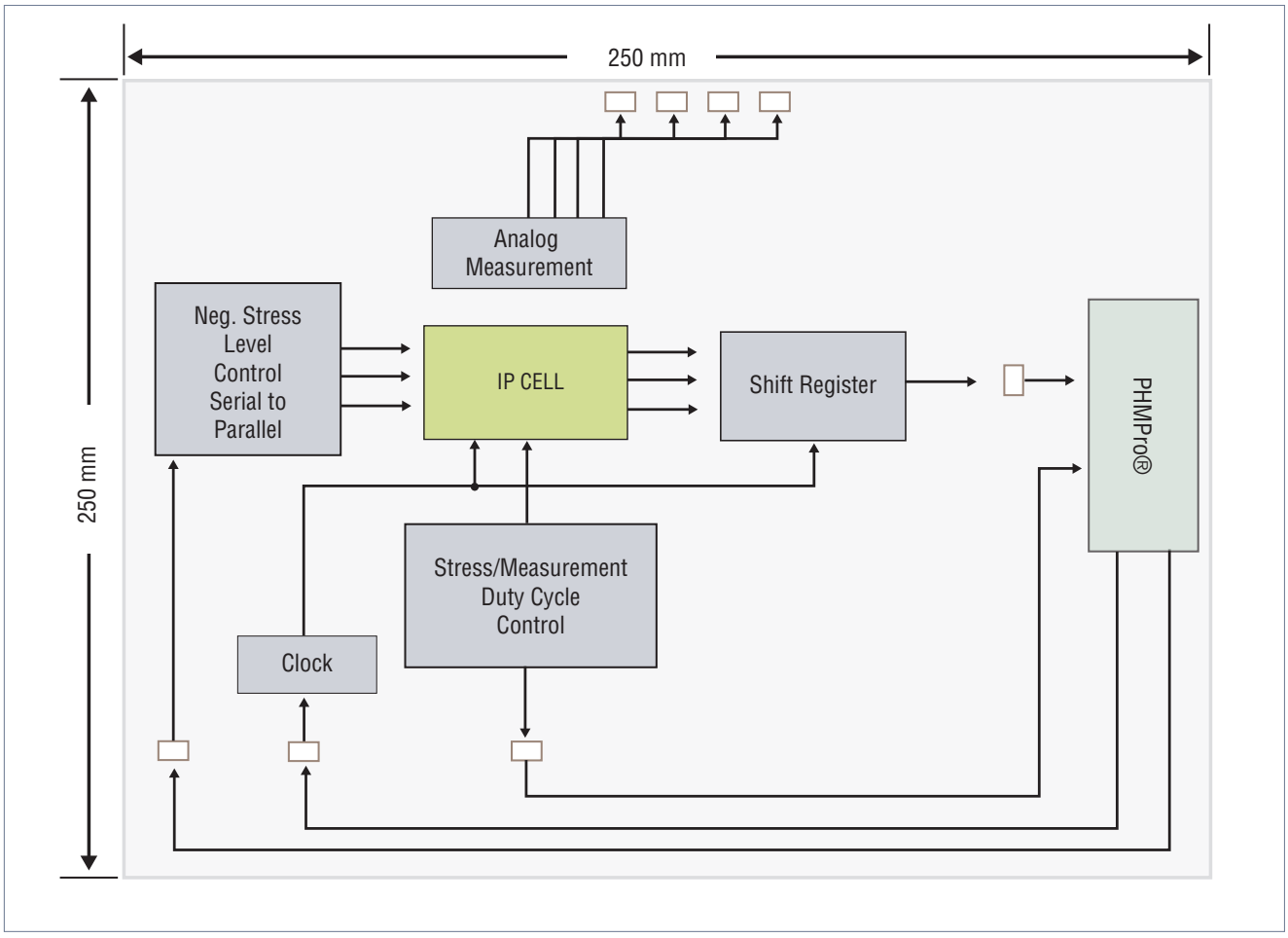

Figure 2: NBTI Prognostic Cell block diagram

Prognostic Distance

Prognostic distance is the time between the prognostic cell warning point and the time of system failure. It can be adjusted to meet customer needs by trigger point calibration.

Figure 3 shows the NBTI cell layout.

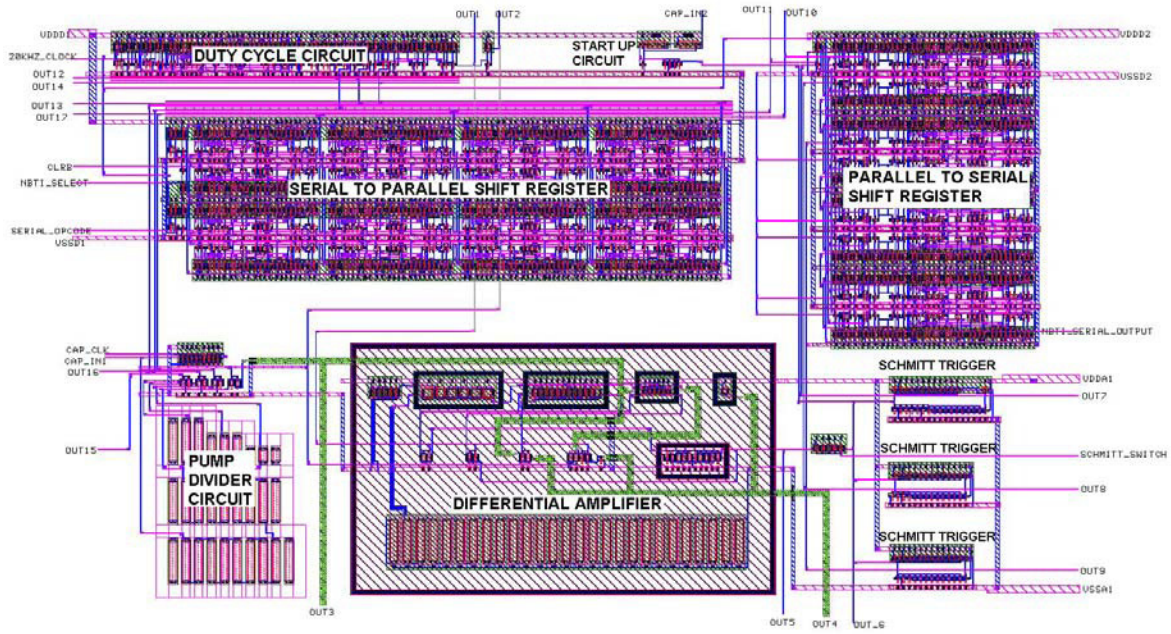

Figure 3: NBTI cell layout

Need modified or custom design? Contact Ridgetop at 520-742-3300 to discuss your ideal solution!

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