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Simulation of SRAM SEU Sensitivity at Reduced Operating Temperatures

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Abstract: *A new NanoTCAD-to-Spectre interface is applied to perform mixed-mode SEU simulations of an SRAM cell. Results using newly calibrated TCAD cold temperature substrate mobility models, and BSIM3 compact models extracted explicitly for the cold temperature designs, indicate a 33% reduction in SEU threshold for the range of temperatures simulated.*

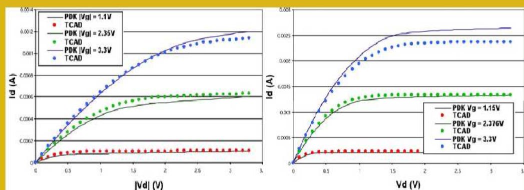
Motivation

- ►**Limited available analyses indicate that single event response may be exacerbated by cold temperature[1-3]**
- ►**Desire to understand worst case SEU threshold of CMOS SRAM in mixed signal system designed using IBM 5AM SiGe BiCMOS[4] to know if higher level mitigation is sufficient approach**

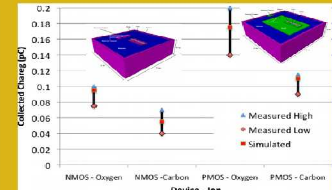
Methodology

►**Calibrate 3D NanoTCAD model vs:**

PDK/Spectre-generated IV curves



Charge collection measured on transistors[5]



- ►**Simulate the temperature dependence of SEU thresholds of SRAM cell using mixed-mode using:**
  - **A new NanoTCAD-to-Spectre interface**
  - **BSIM3 models extracted explicitly for the cold temp design**
  - **Newly calibrated TCAD cold temp substrate mobility models**
    - **Lombardi model[7] for MOSFETs with modifications to how internal values are calculated at low temperatures, based on the models in Selberherr[8].**
    - **Altermatt model[9,10] for incomplete ionization, that internally calls newer effective mass and bandgap model[11].**

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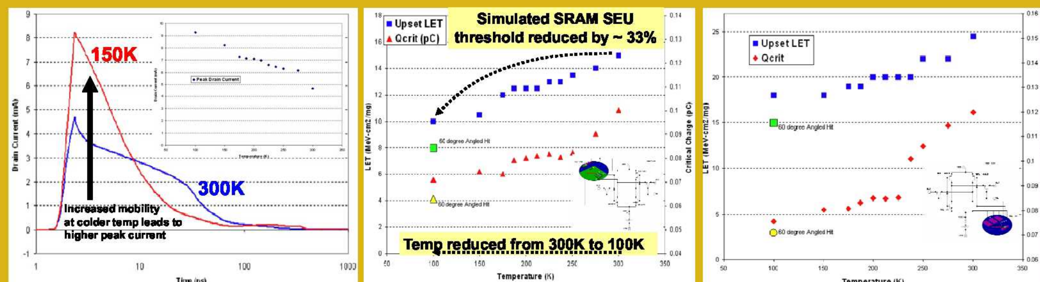
Findings

►**Peak SE-induced current increases with decreasing temperature**

►**Simulations indicate ~ 33% reduction in upset threshold for the range of temperatures simulated.**

►**The simulated minimum threshold, even for an angled (60°) strike, is well above the threshold for direct ionization by protons (equivalent to LET ~ 0.5 MeV-cm²/mg).**



Conclusions

►**Use of common higher-level mitigation techniques for SEU is sufficient in this technology and design; no cell level hardening required**

►**Temperature should be considered when possible and appropriate in testing and analyses of single event effects[6]**

►**Capability to couple TCAD to Spectre allows mixed mode simulations using vendor supplied PDK compact models directly**

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