



Dose and Microdose Measurement based on Threshold Shifts in MOSFET arrays in Commercial SRAMS

L. Z. Scheick and G. M. Swift

Jet Propulsion Laboratory, Pasadena, Ca

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Introduction



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- **Dosimetry Based on Integrated Circuits**
 - ◆ Determine metric (e.g. retention time for DRAM) and measure change with dose
 - ◆ Many individual small dosimeters acting in statistical union
 - ◆ Procedure successfully done on Floating Gate, DRAM, and optical technology
 - **SRAM based threshold method offers advantages**
 - ◆ Digital input/output
 - ◆ Easy access to cells
 - ◆ COTS technology
 - Diverse devices
 - COTS radiation softness



Dosimeter Requirements and Method



- **Dosimeter must**

- ◆ Good resolution
- ◆ Low power
- ◆ Simple preparations/measurements
- ◆ Thermally insensitive/compensated
- ◆ Use external pins only
 - Remote dosimetry application

- **Method**

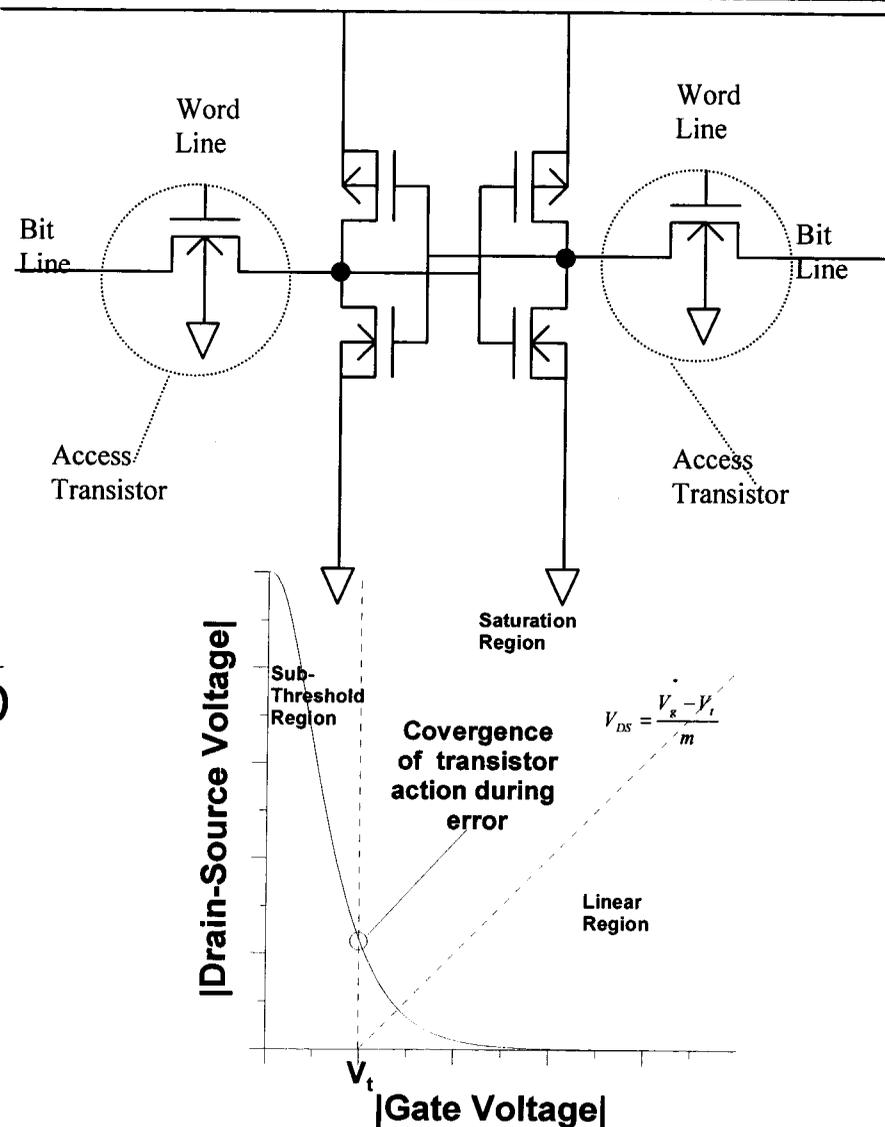
- ◆ Ramp down voltage and readout at each increment
- ◆ Record number of errors as function of voltage level
 - On Vcc and I/O pins
- ◆ Shift in distribution will correlate to dose



CMOS SRAM Cell

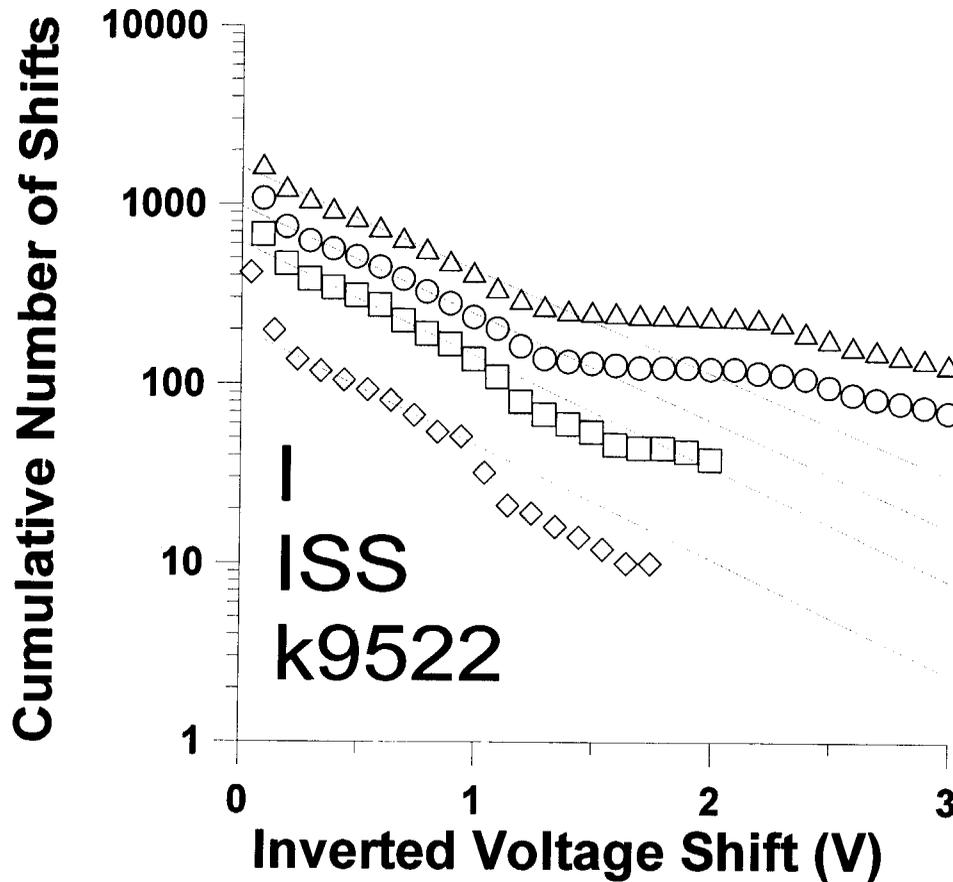
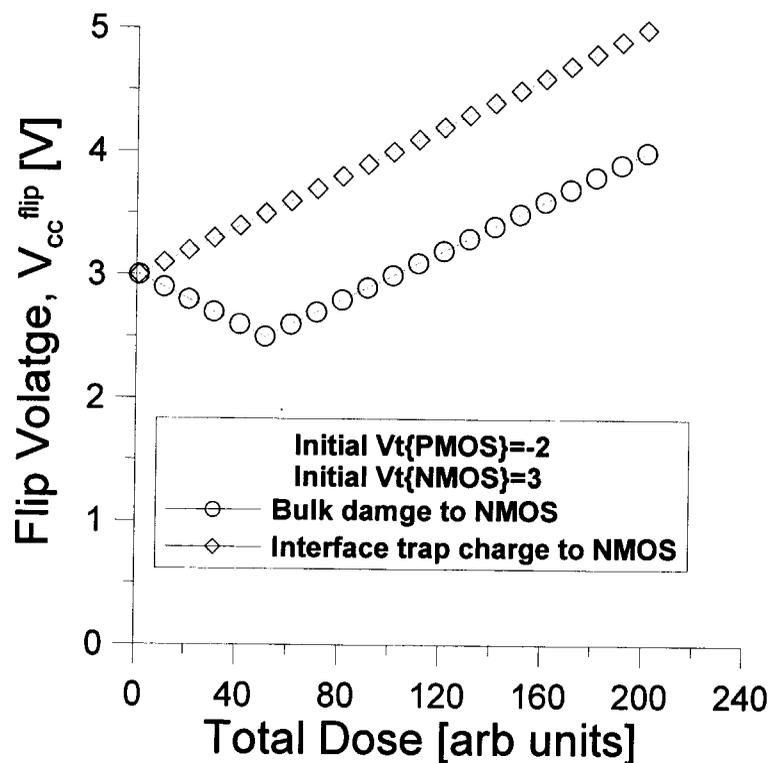


- MOSFETs on ICs have thin gate oxides
- Bimodal SRAM cell response
 - ◆ NMOS with no rebound
 - minimal response to TID
 - ◆ NMOS with rebound
 - Measurable response to TID
- Sub-threshold operation enough to hold state





Response to voltage ramp down **JPL**





Dosimetry issues and conclusions



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- **Device insensitive to gamma total dose**
 - ◆ Symmetry of SRAM cells may not be broken
 - N-channel devices have no negative shift
 - ◆ Cell radiation response may outpace peripheral circuitry
 - **CMOS peripheral circuitry limits dynamic range**
 - ◆ Passive mode will be investigated
 - ◆ Peripheral circuitry can be shielded
 - **Part-to-part variation is not an issue**
 - **Irradiation mode may be an issue**



Microdosimeter Requirements and Method



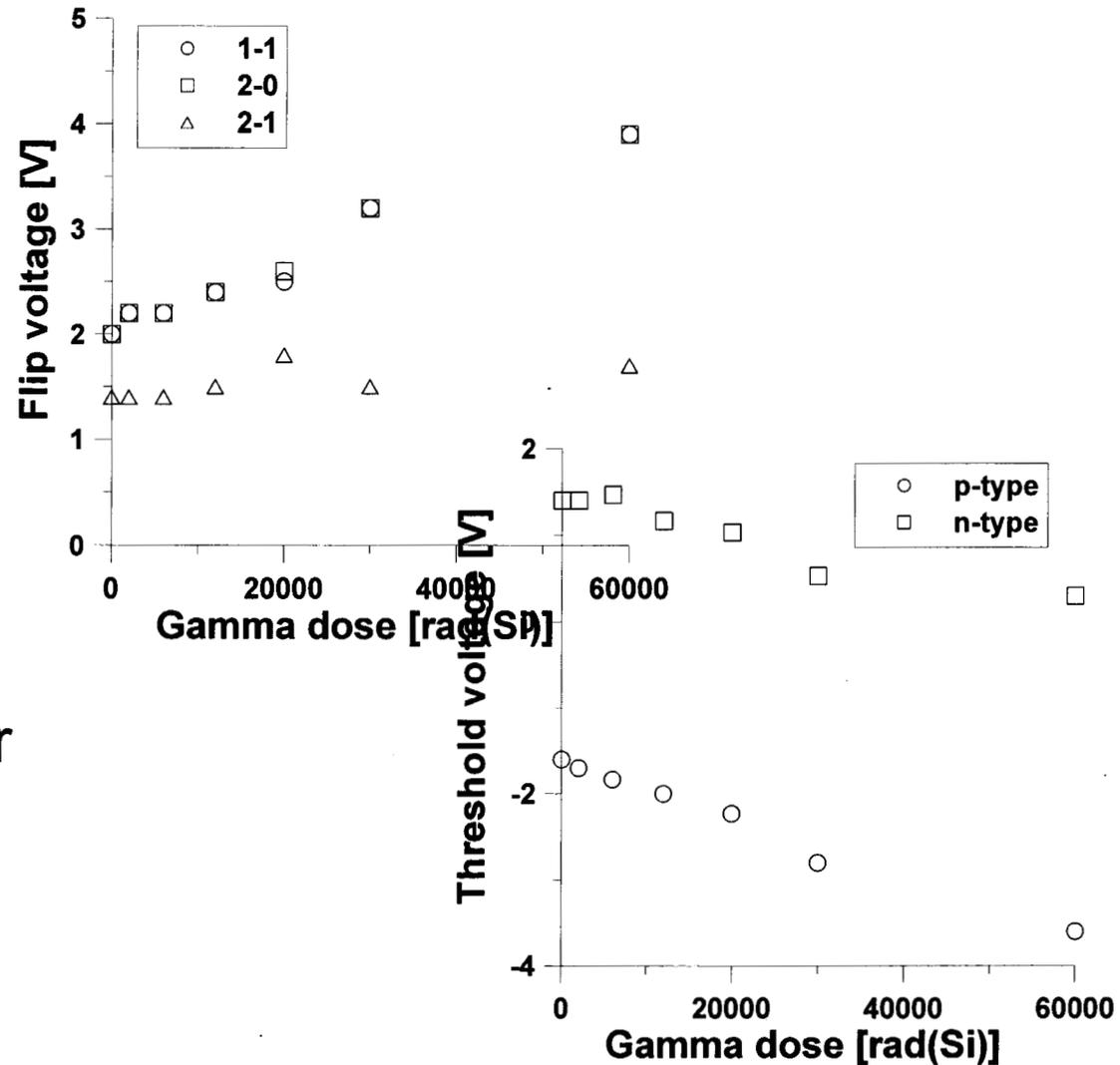
- **Microdosimeter must**
 - ◆ Low tolerance of false positives
 - Due to noise
 - 1 per 100 readings
- **SRAM sensitive volume is gate oxide**
 - ◆ Microdose to SV will cause SRAM symmetry to breakdown and fail at higher voltage
- **Method**
 - ◆ Ramp down voltage and readout at each increment
 - ◆ Record threshold of each bit
 - ◆ Shift in threshold voltage of each bit will correlate to microdose
 - ◆ Shifts should depend on fluence and LET



Single cell analysis method

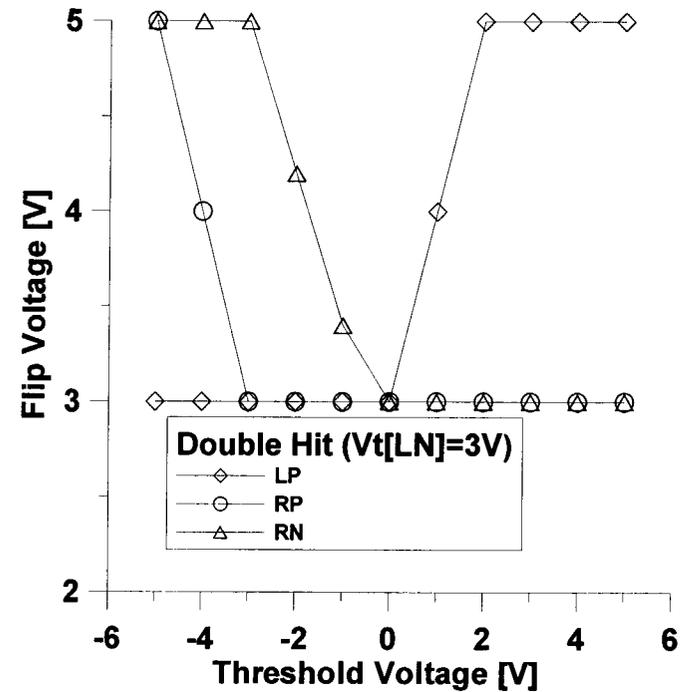
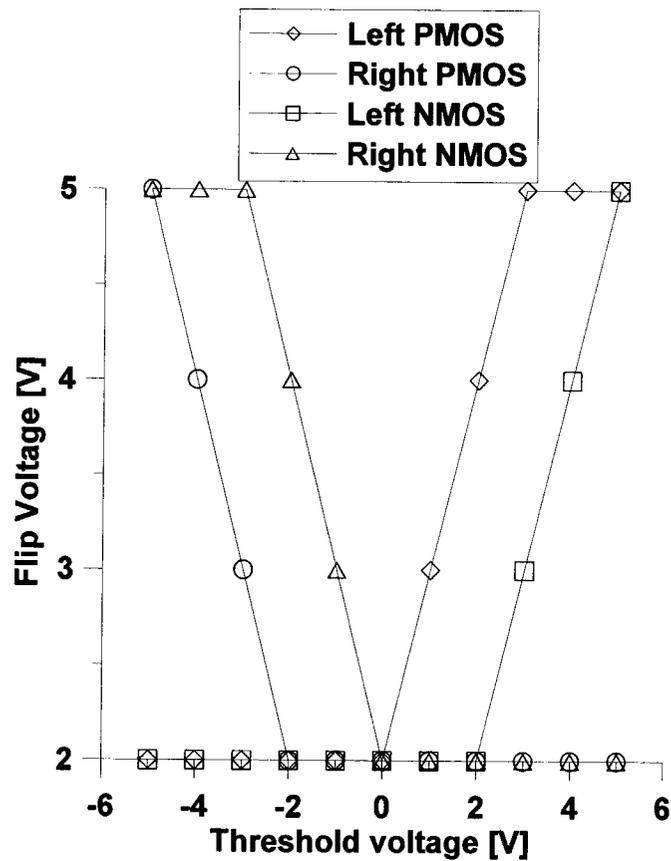


- Each threshold can be recorded for individual dose measurement
 - ◆ Sensitive volume is gate oxide of all four MOSFETs



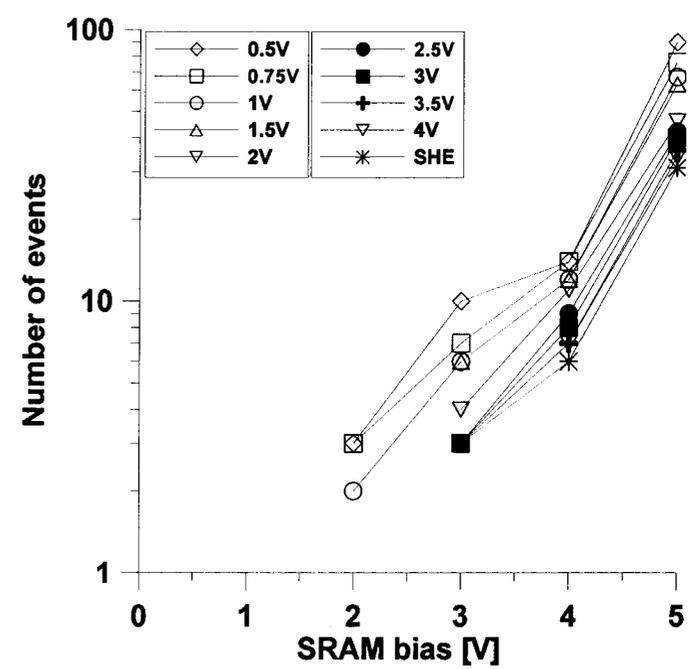
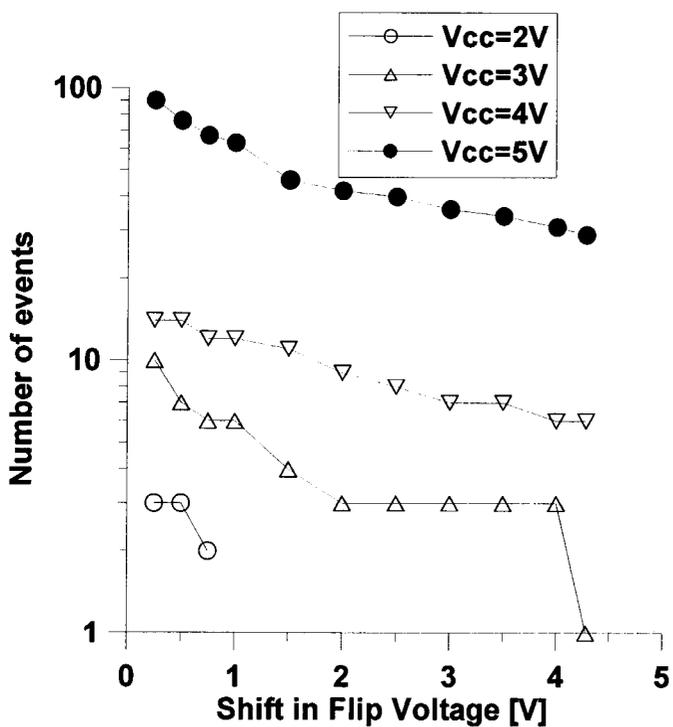


Single SRAM cell results





Number of strong shifts for two ions





Microdosimetry issues and conclusions



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- **Slightly LET dependent**
 - ◆ Number of shifted cells
 - ◆ Magnitude of shift
 - **Bit selection process is unimportant**
 - ◆ Manufacturing variation across die
 - **SHE are seen in some devices at 5V readout**
 - **Irradiation mode may be an issue**
 - **Applications**
 - ◆ Single Event oxide monitor
 - ◆ Solar flare heavy ion detector