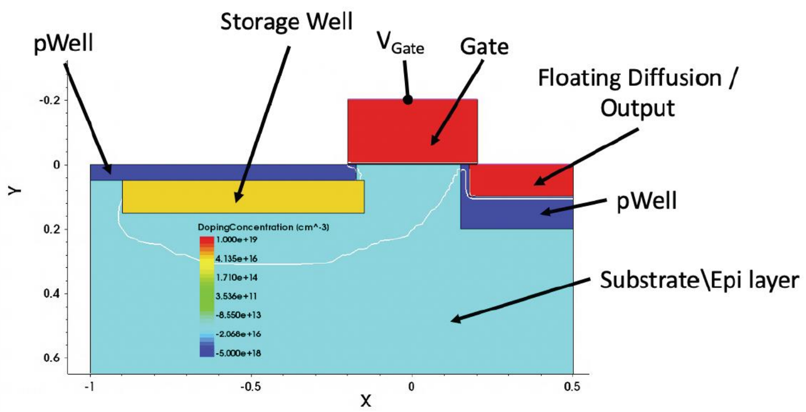
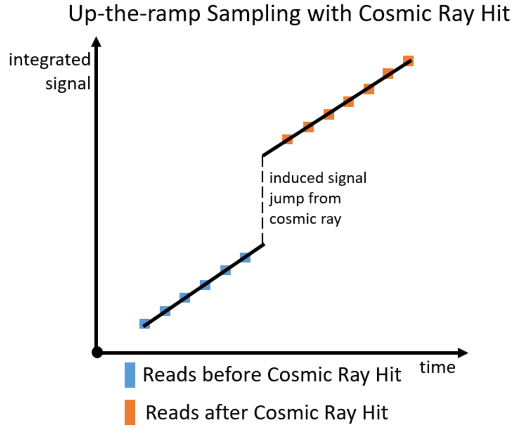
Advancing Radiation-Hardened CMOS Detectors for NASA Missions Don Figer/ Center for Detectors at RIT





The upper panel shows a simulated single-photon sensing NIR photodiode that is similar to a proposed design. The lower panel shows a proposed read mode that is optimized for signal-to-noise ratio in the presense of cosmic rays.

Research Objectives

1. create and validate SEU-mitigation readout modes against metrics
   a. IR detectors use SOA cosmic ray rejection read modes but high-gain CMOS detectors do not.
   b. Entry TRL 2/exit TRL 3: technology concept is formulated but no experimental proof is implemented in CMOS optical devices.
2. create and test radiation damage mitigation operational modes
   a. SOA operational modes tune detector biases due to flat-band shift.
   b. These operational modes are not implemented in high-gain CMOS detectors.
   c. Entry TRL 2/exit TRL 3: technology concept is formulated but little to no experimental proof of the effectiveness at reducing effects from Mrad doses.
3. identify characteristic radiation effects in high-gain CMOS detectors
   a. Characteristic radiation effects in these detectors are not investigated.
   b. Both ionizing and non-ionizing effects will be measured on the detector, logic, and digitization circuit.
4. design single-photon counting NIR photodiode
   a. The starting point of will be the optical high-gain detector design.
   b. It will enable new science capabilities and missions using these NIR photodetectors with <<1 e- read noise.
   c. SOA NIR photodiodes have a read noise of 4-5 e^-.
   d. Entry TRL 2/exit TRL 3: the technology concept is formulated but no experimental proof of these operational modes are implemented in CMOS optical devices.

Approach

1. use existing detector packages and perform cryogenic characterization
2. irradiate devices and conduct post-radiation characterization
3. identify characteristic effects
4. develop and validate new readout and operational modes for cosmic ray rejection
5. measure effectiveness of new readout and operational modes during radiation test program
6. design and simulate a single-photon counting NIR photodiode

Potential Impact

1. advance radiation tolerance of high-gain CMOS detectors to soft single-event effects and permanent damage
2. design single-photon sensing and photon-number resolving high-gain NIR detector enabling new science capabilities and missions
3. guide development of future single-photon counting high-gain CMOS image sensors
4. fabricate of Gpixel FPAs and SCAs on a single wafer
5. broaden instrument design space to decrease weight and cost while improving performance and maintaining detector reliability