New RADFETs for Space Applications

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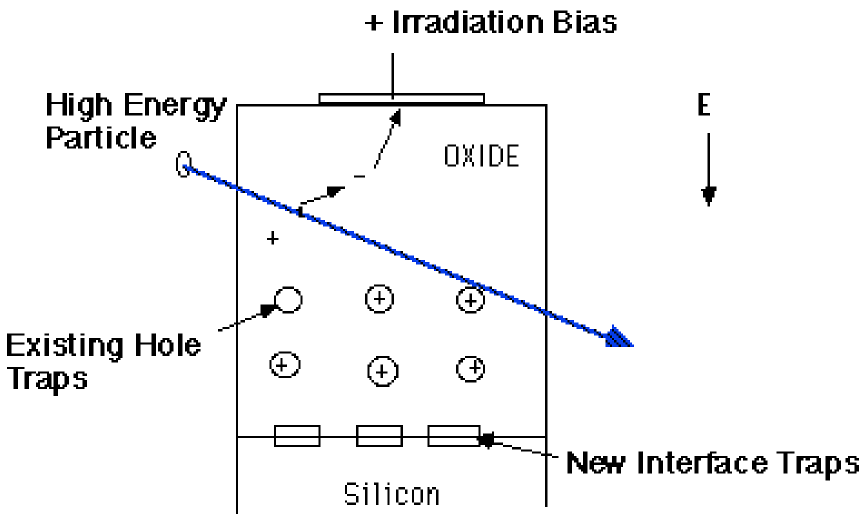
Outline:

- Basics of RADFET operation
- Overview of the work performed
- Main results:
  - Effects of gate process changes
  - Dose rate dependence
  - Detailed calibration of selected batch
  - Densities of radiation induced defects
- Future work

RADFET operating principle:

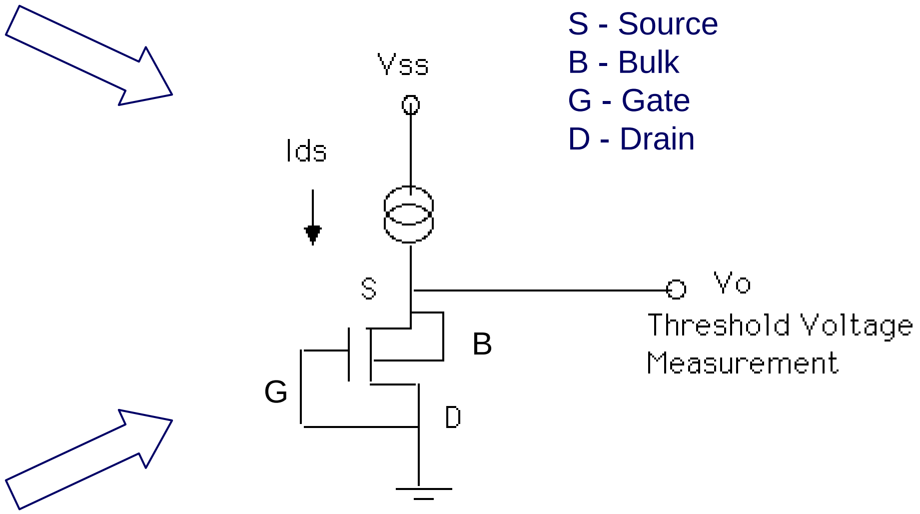


- Radiation creates electron-hole pairs
- Initial recombination of electrons and holes happens
- Non-recombined electrons leave the oxide;
  holes are trapped in the vicinity of the oxide/silicon interface
- RADFET threshold voltage (V_T) changes ($\Delta V_T \sim$ Dose)

RADFET biasing configurations:

- Irradiation (sense mode): zero current; (B, S and D grounded); G can be:
  - Grounded ($V_{IRR}=V_{GS}=0V$) (option 1)
  - Biased (typically $V_{IRR}=V_{GS}>0$) (option 2)

  Read-out mode: specified current applied to S=B; G=D grounded



- Irradiation (sense mode) and Read-out mode are the same (option 3)

RADFET advantages over other dosimeters:

- Immediate read-out without destroying the data
- Extremely small sensor chip
- Very low or zero power consumption
- Electronic signal
- Low cost (especially of a reader device)

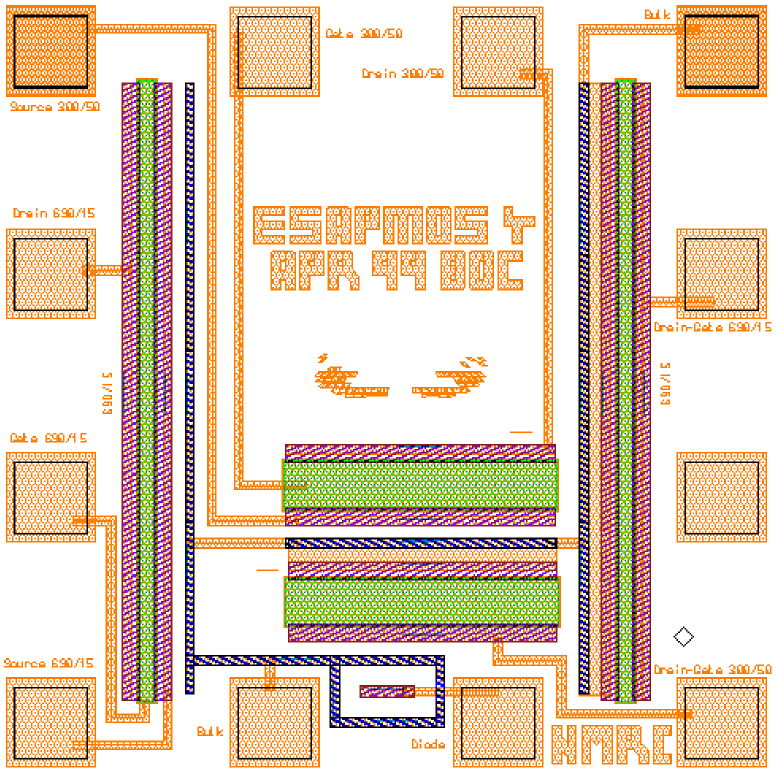
Applications:

- Nuclear industry and research
- Space dosimetry
- Radiotherapy
- Personal dosimetry [?]

Overview of main project tasks:

- Produce new types of RADFETs:
  - Standard batch with new V_T adjust (B1)
  - Batch with increased time and temp. of post-implant anneal (B2)
  - Batch with additionally increased temp. of post-implant anneal (B3)
  - Two batches with oxide-nitride sandwich (4 and 5)
- Perform Co-60 calibration and study dose rate dependence
- Characterise densities of radiation-induced charges
  - Subthreshold-midgap technique
  - Charge Pumping

ESAPMOS4 RADFET chip:



- Chip size: 1mm x 1mm
- Contains four RADFETs:
  - two 300/50 devices
  - two 690/15 devices
- Chip types (gate oxide):
  - 100 nm
  - 400 nm
  - 400 nm Implanted (IMPL)
  - 1 μm
  - 1 μm Implanted (IMPL)

Effects of gate process changes (post-implant anneal temperature increases from B1 to B3):

- Sensitivity at +5V bias increases from B1 to B3
- Sensitivity at 0V bias decreases from B1 to B3
- Fading decreases from B1 to B3
- Effects are a consequence of altered properties of oxide- and interface traps
  - Publication on this is being finalised for NSREC 2009
  - Analysis of trap densities is critical in any development

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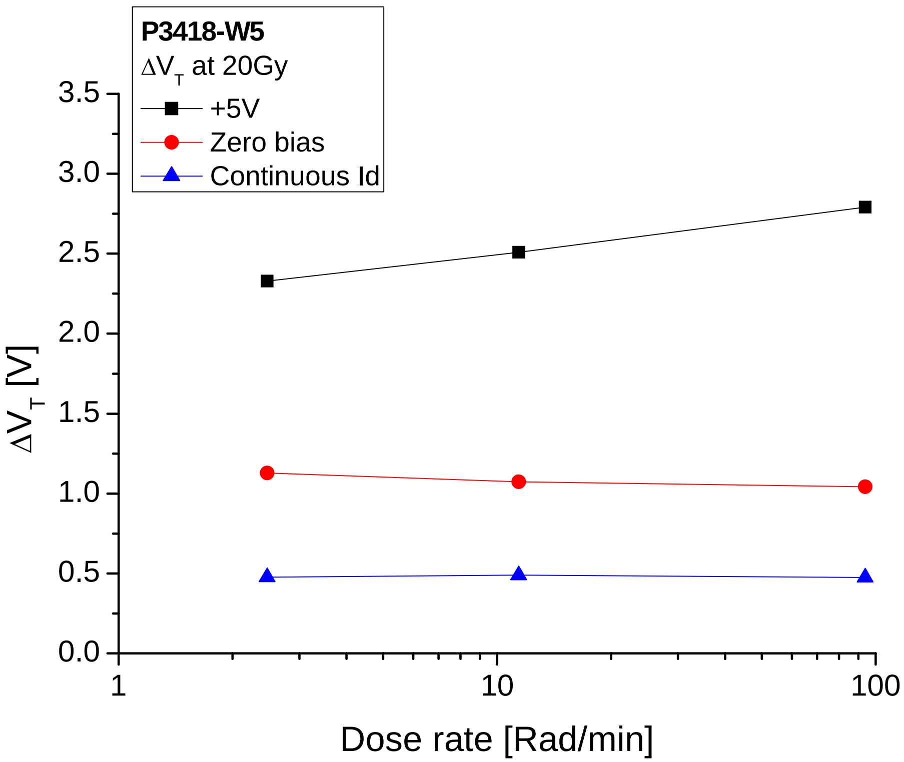
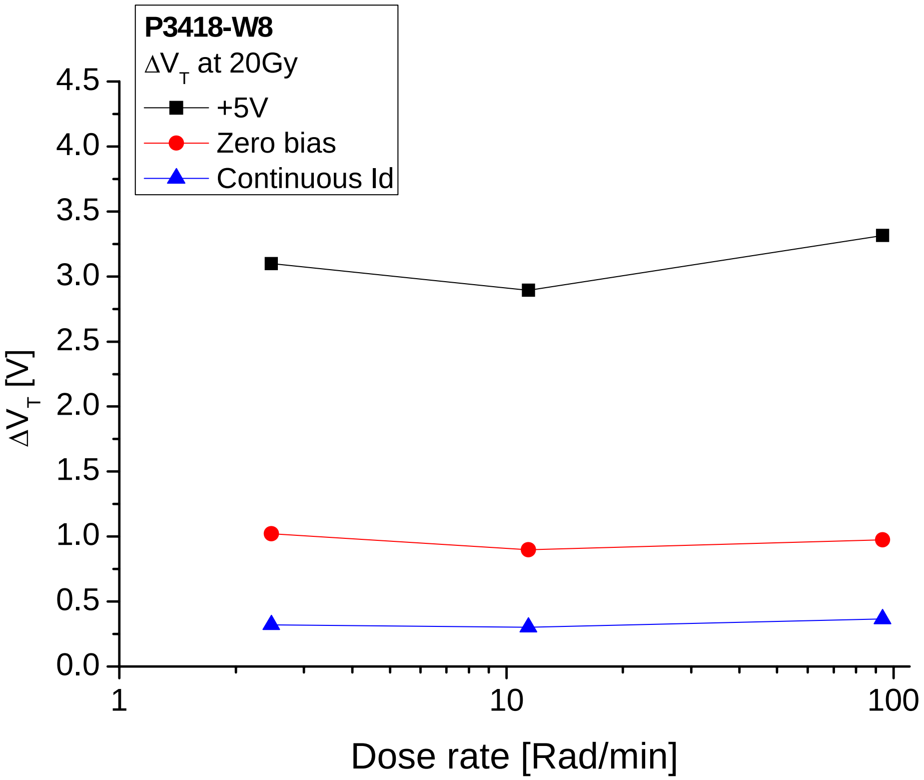
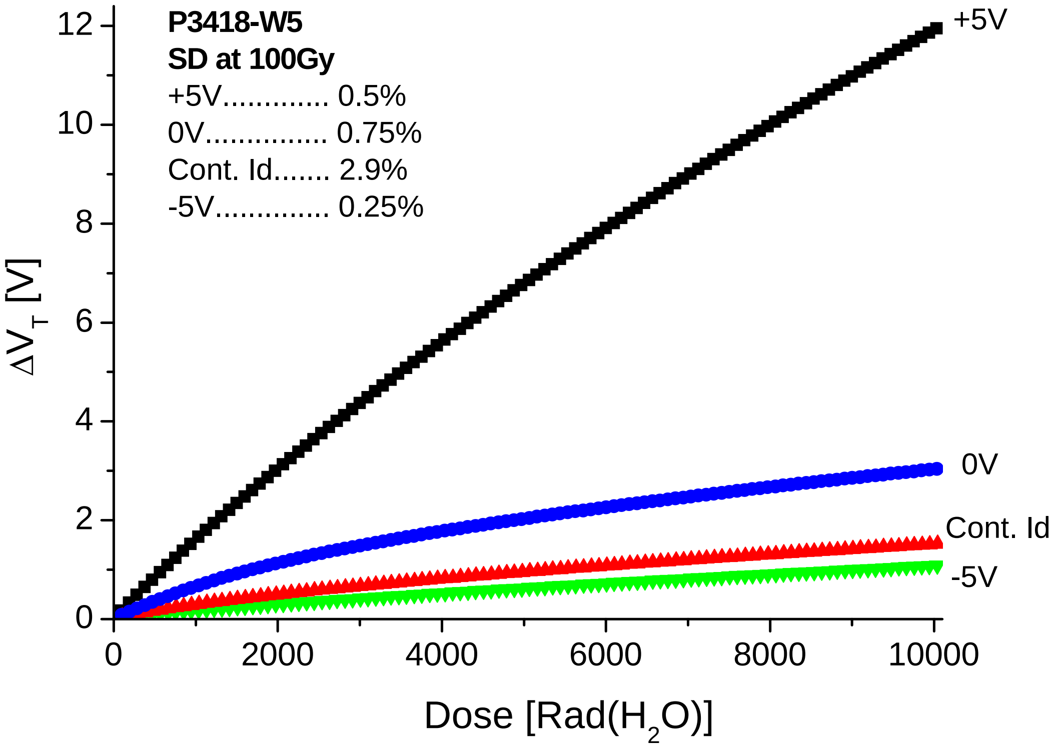
Dose rate dependence (B1: P3418-W5):



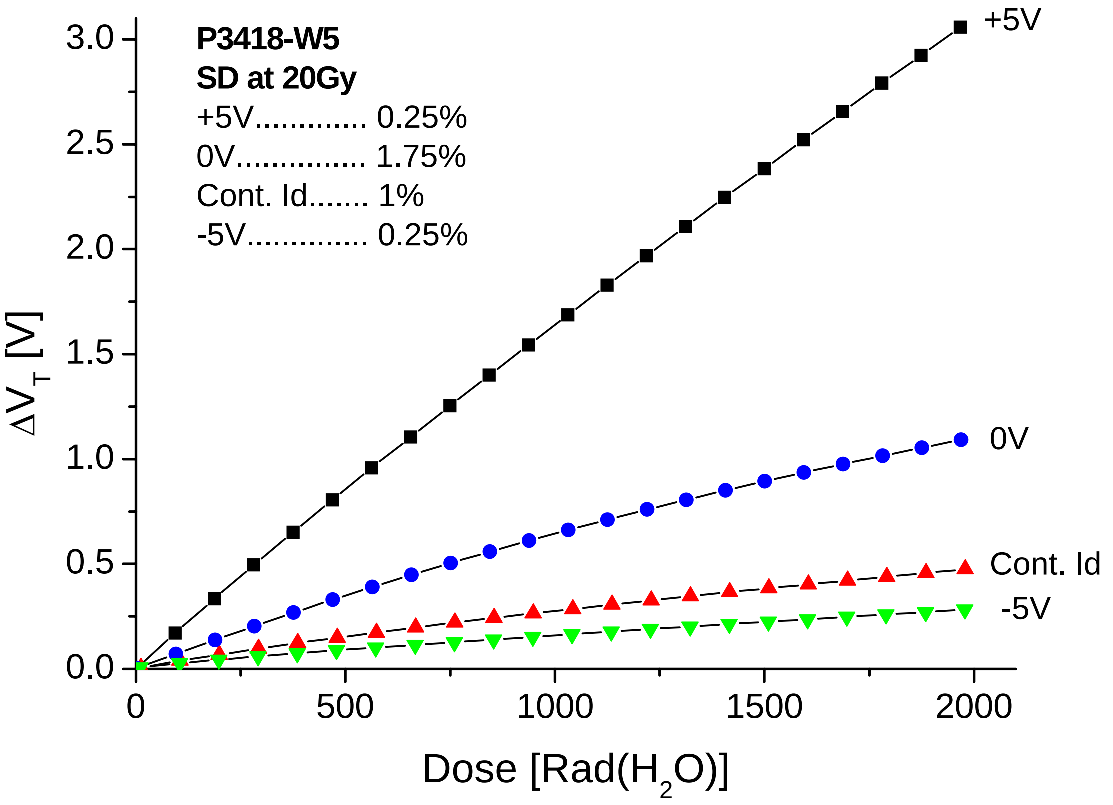
Dose rate dependence (B2: P3418-W8):



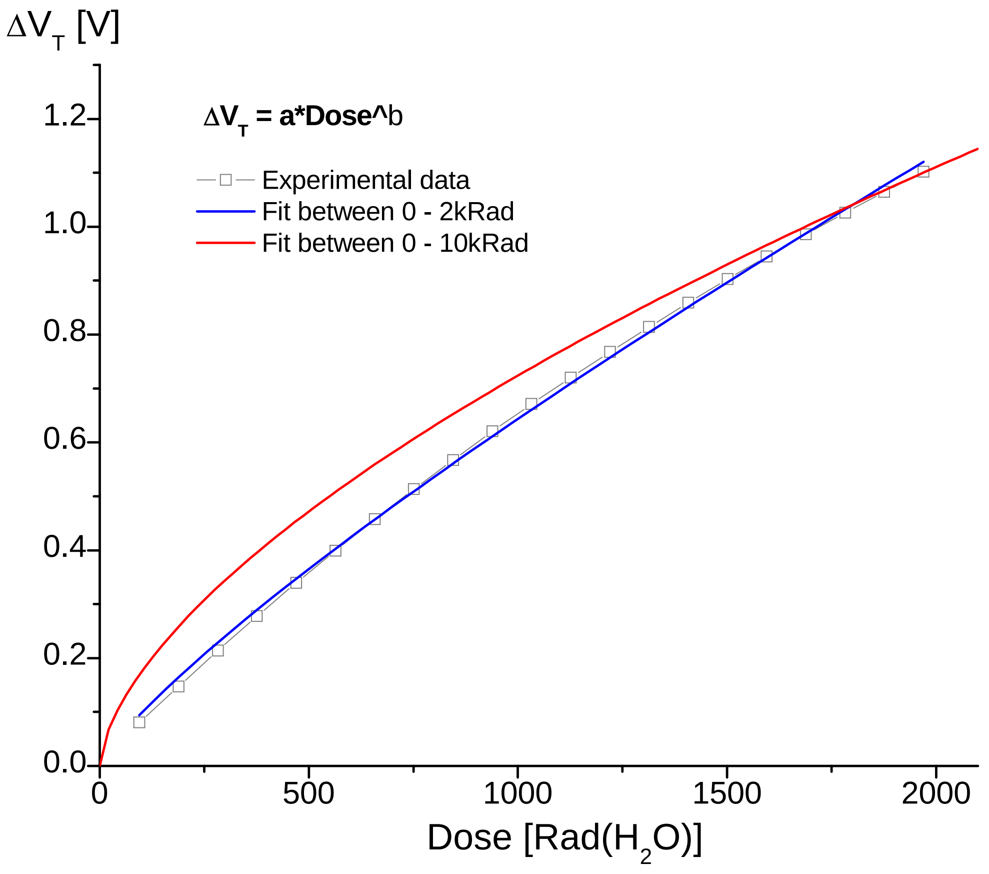
Calibration curves (P3418-W5; 100 Gy):



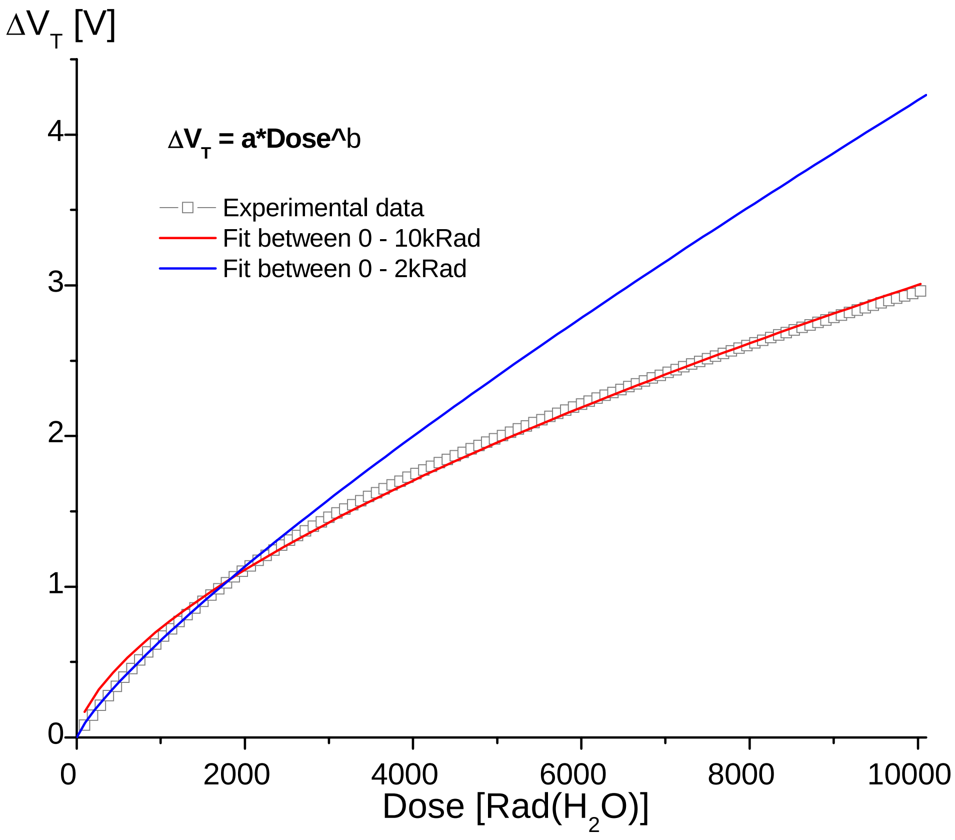
Calibration curves (P3418-W5; 20 Gy):



Fitting range is critical (1):



Fitting range is critical (2):



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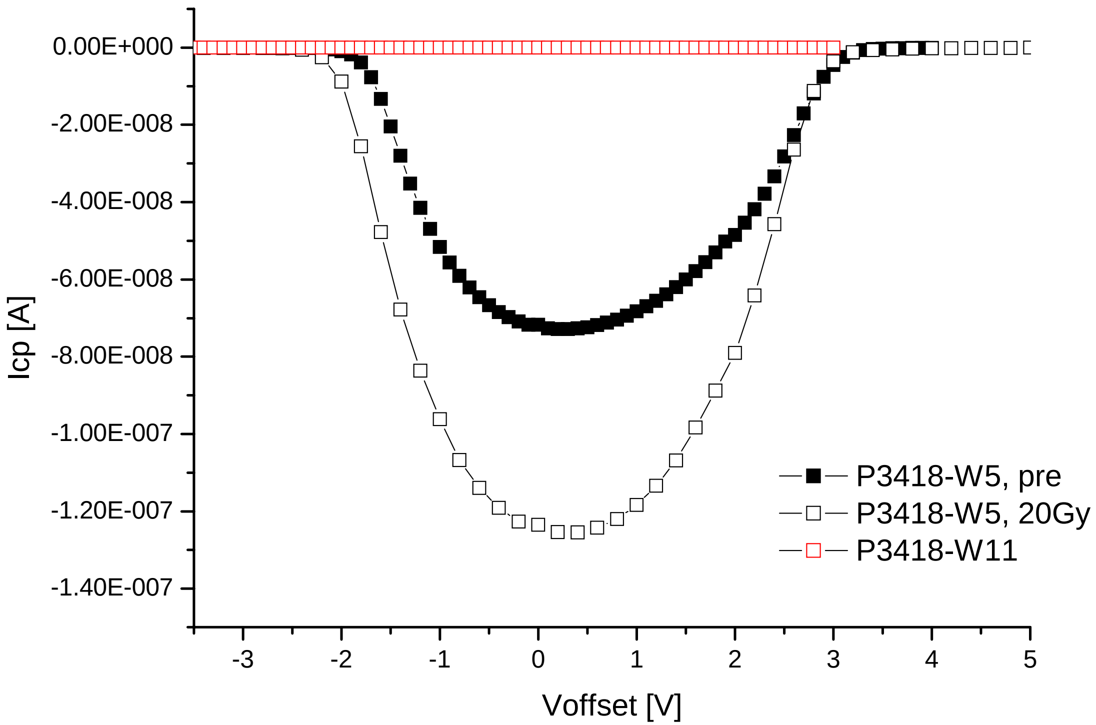
Charge pumping curves:



Conclusions:

- New RADFET batches successfully produced
- Effects of gate oxide process changes observed
- No dose rate dependence observed in tested range
- Very uniform RADFET response
- Care should be taken when choosing fitting ranges

Proposed future work:

- Production of flight samples for upcoming missions
  - Alphasat
  - Globalstar
  - Galileo programme
- RADFET characterisation
  - Upcoming missions
  - Additional characterisation of new RADFET types
- Improvements of the RADFET reader

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