Ongoing and planned RADFET developments

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Aleksandar Jaksic, Brendan O'Neill

Tyndall National Institute, Cork, Ireland

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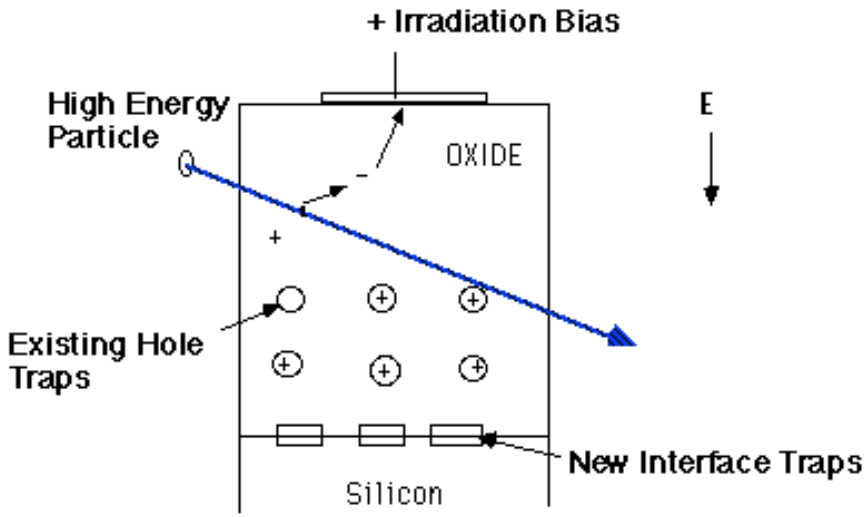
Outline:

- What is RADFET and how does it work?
- Threshold implant optimisation
- Stacked RADFETs
- From space to terrestrial applications
- Success story: INVORAD

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 advantages over other dosimeters:

- Immediate read-out without destroying the data
- Extremely small sensor chip
- Very low or zero power consumption
- Technology suitable for connection to a microprocessor
- Comparatively low cost

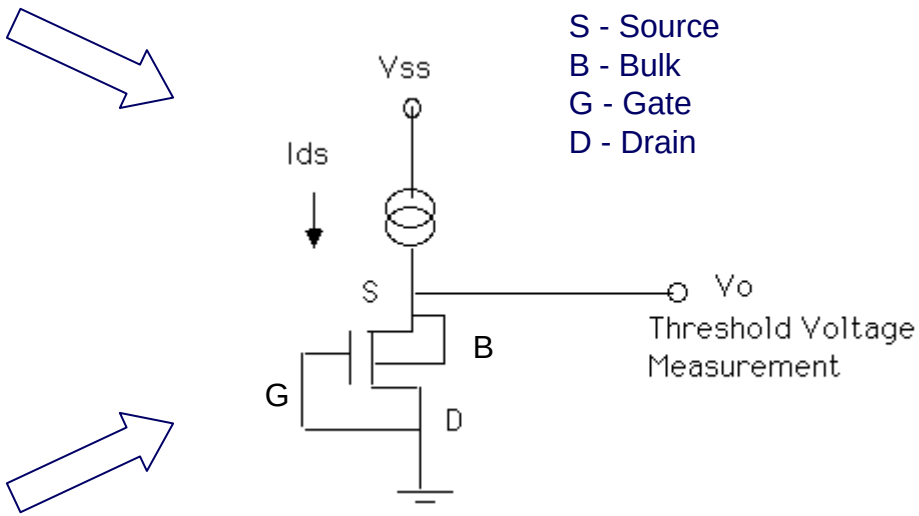
Applications:

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

RADFET biasing configurations:

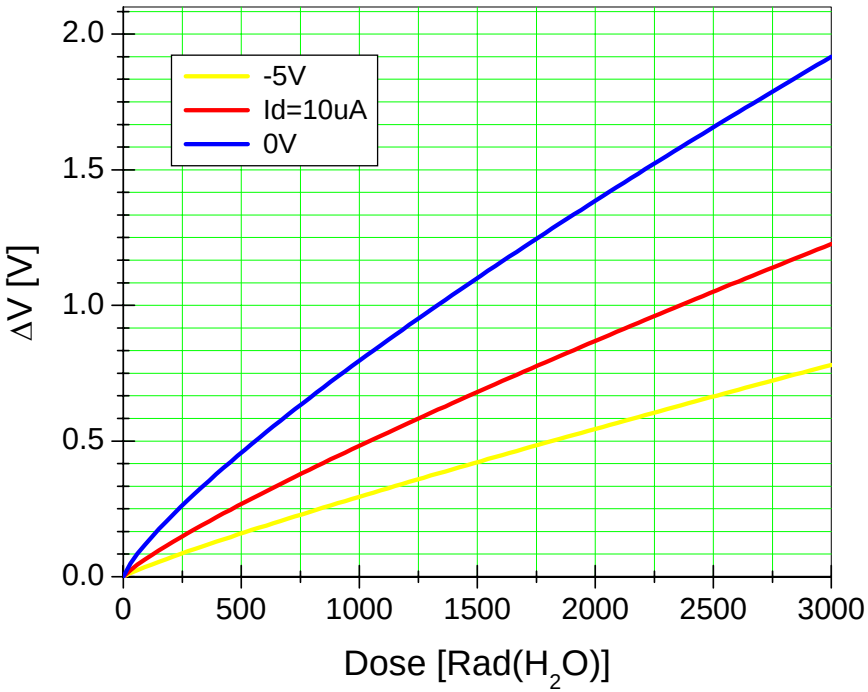
- Irradiation (sense mode): zero current; (B, S and D grounded); G can be:
  - Grounded ($V_{IRR}=V_{GS}=0V$)
  - Biased (typically $V_{IRR}=V_{GS}>0$)

  Read-out mode: specified current ($Ids=I_O$) applied to S=B; G=D grounded



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

Co-60 calibration curves:



Calibration coefficients

The curve equation is of the form: $\Delta V = a \times Dose^{b}$; ΔV[Volts], Dose[Rad(H_2O)].

Bias	a	b	R-square	SSE
-5V	0.000643	0.8871	0.9999	0.00042
Cont Id=10μA	0.001365	0.8494	0.9994	0.00475
0V	0.003166	0.8001	0.9976	0.04626

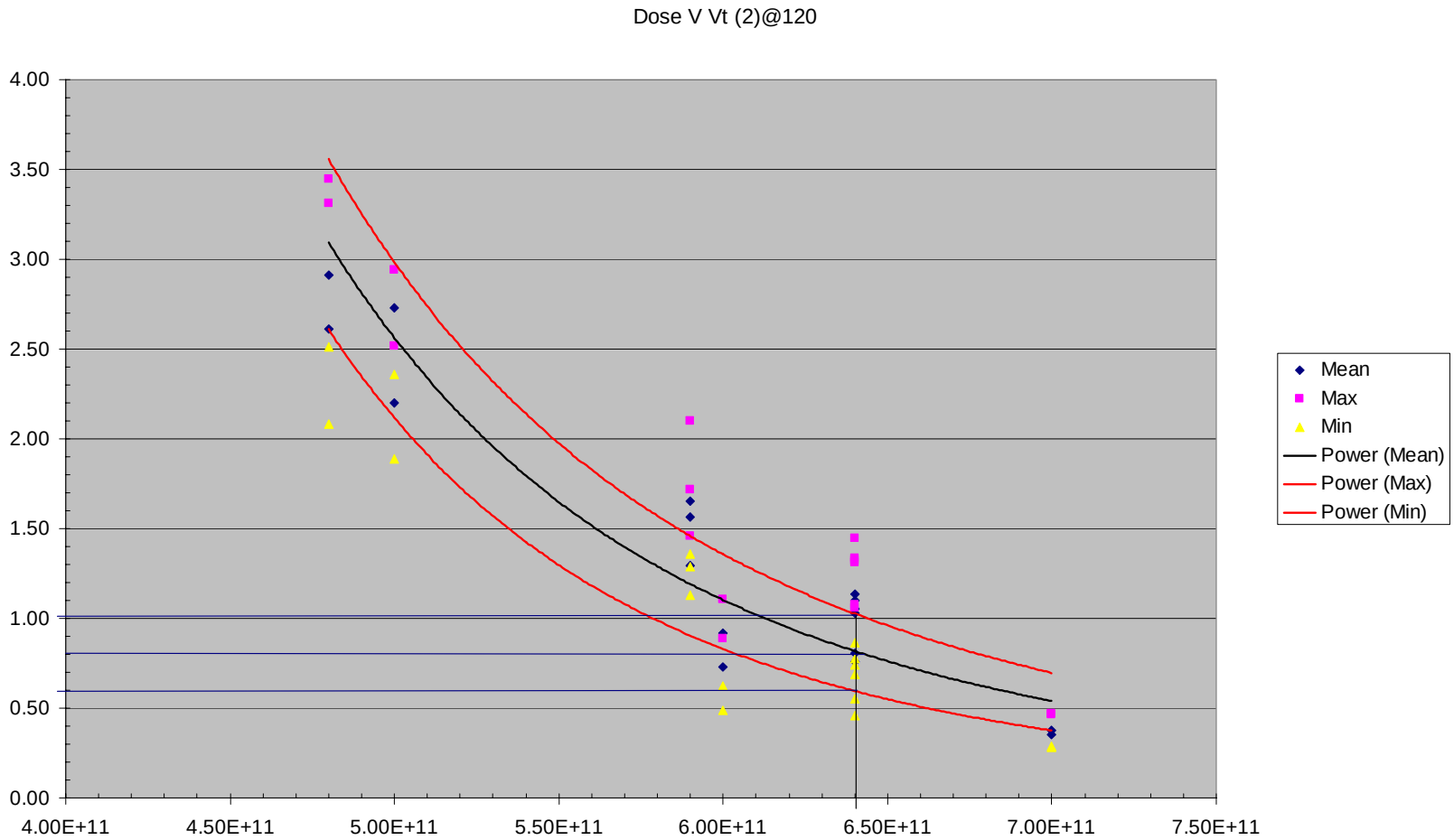
Preferred biasing configurations:

- Zero gate bias (V_{IRR}=0V)
  - ✓ Good sensitivity
  - ✓ Low fading
  - × Need to switch between irradiation and read-out mode
- Continuous I_o
  - × Somewhat decreased sensitivity
  - ✓ Low fading
  - ✓ No need for switching between irradiation and read-out mode

Threshold implant:

- “Native” Vth of 400nm oxide: ~8V
- Task: reduce Vth to ~0.8V (1.5V)
- Benefits:
  - Higher voltage range
  - Increased sensitivity
- Implant optimisation:
  - Implant dose (1/cm^2)
  - Implant energy (keV)

Threshold implant optimisation (dose):



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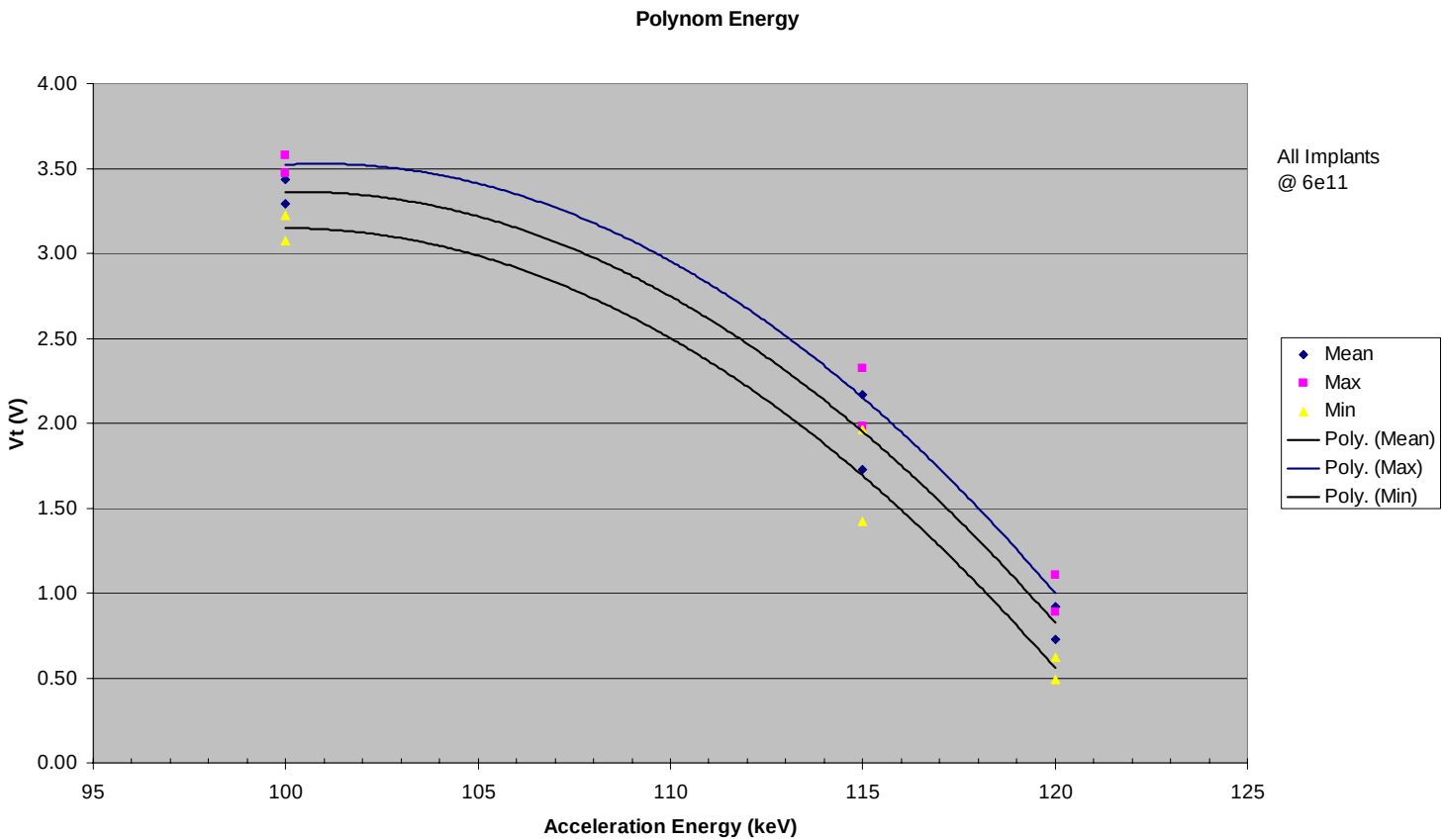
Threshold implant optimisation (energy):



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RADFET Reader Board System:

- Completely autonomous, easy to use system
- Reads up to 40 RADFETs in sequence
- Flexible RADFET biasing options
- Data saved in Excel files

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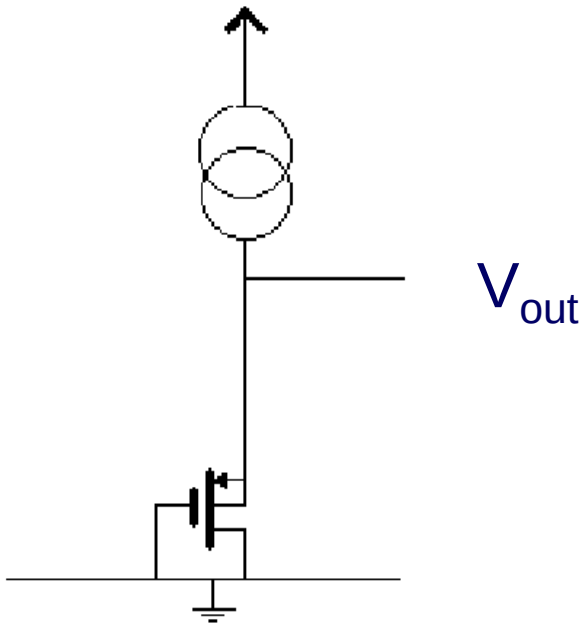
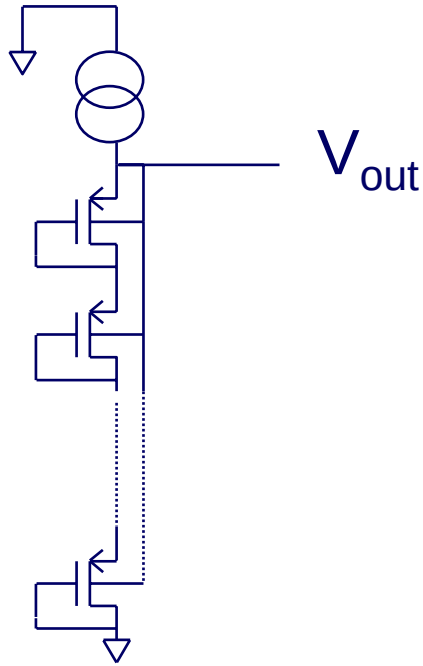
Stacked RADFET:



Single



Stacked

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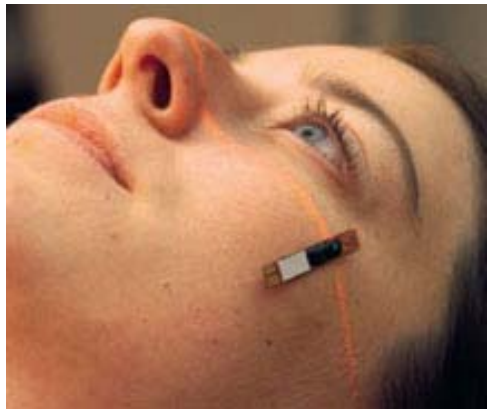
From space to terrestrial applications:



OneDose (Sicel)

DVS (Sicel)

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INVORAD project (www.invorad.com):

RADFET catheter line array

Delta^4 (ScandiDos)