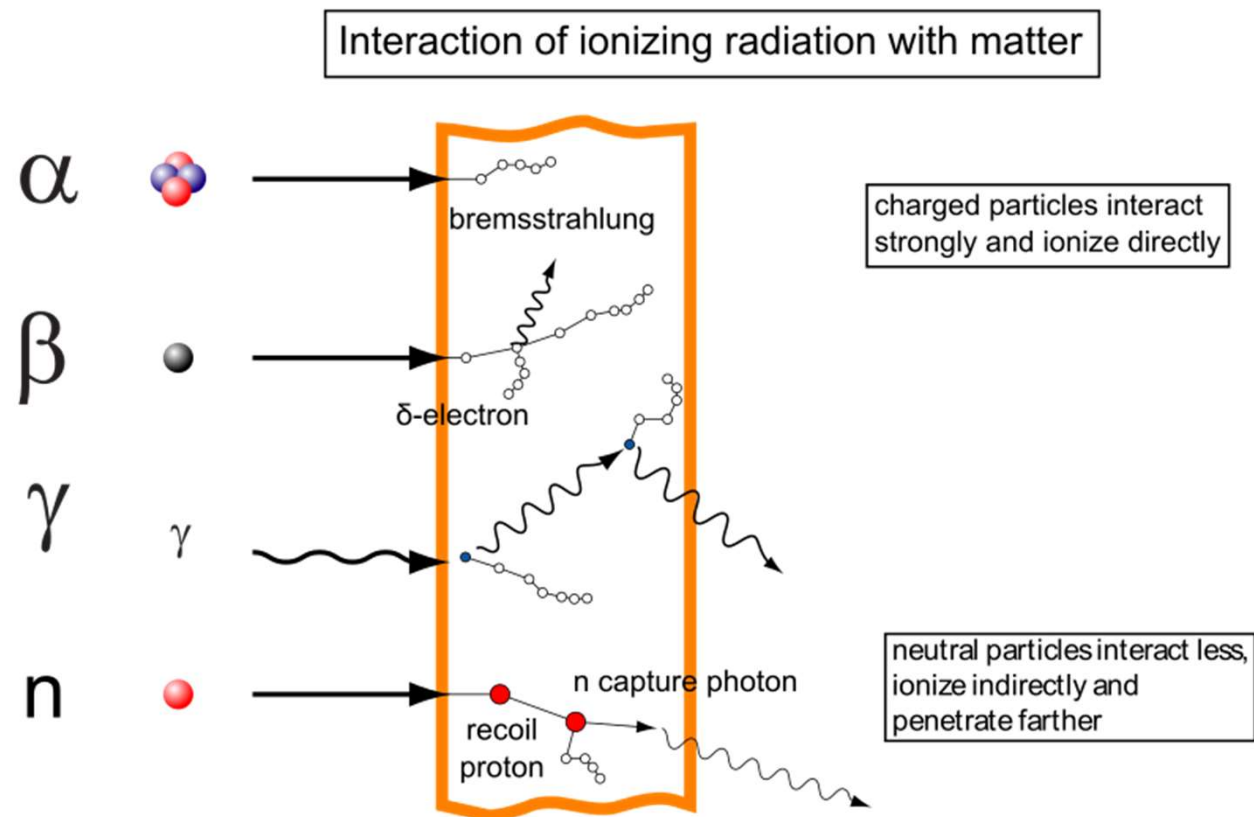


Introduction to Semiconductor Radiation Detectors

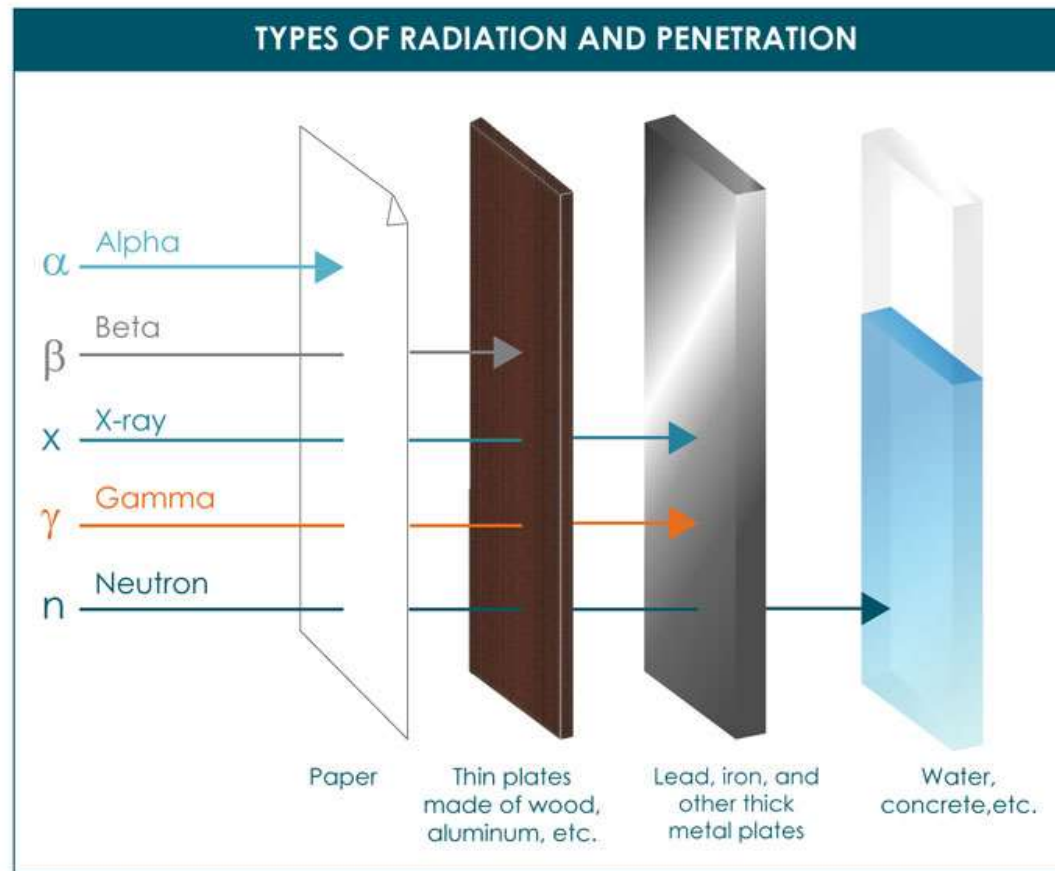
Aleksandar Jaksic

2nd ELICSIR Training School
21 April 2021

Ionising radiation types...



... and ranges



Applications of radiation detectors



MEASUREMENT



PROTECTION

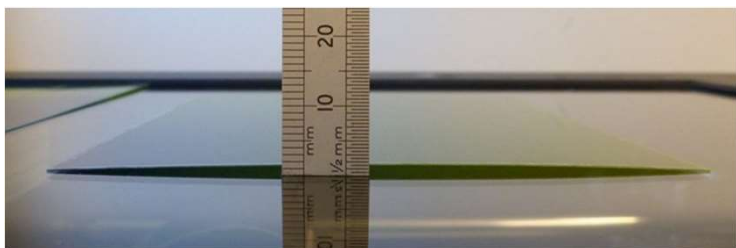


SEARCH

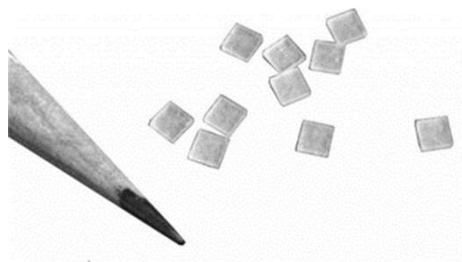
Types of radiation detectors

- PASSIVE
 - Film
 - TLD
 - OSL
- ACTIVE
 - Gas filled (Ionisation Chamber, Proportional Counter, GM Counter)
 - Scintillators
 - Semiconductor (Solid-state)
 - ✓ Ge
 - ✓ CdZnTe
 - ✓ Direct Ion Storage (DIS)
 - ✓ Diode
 - ✓ RADFET (MOSFET)

Passive detectors in radiotherapy



Ashland's EBT3 film



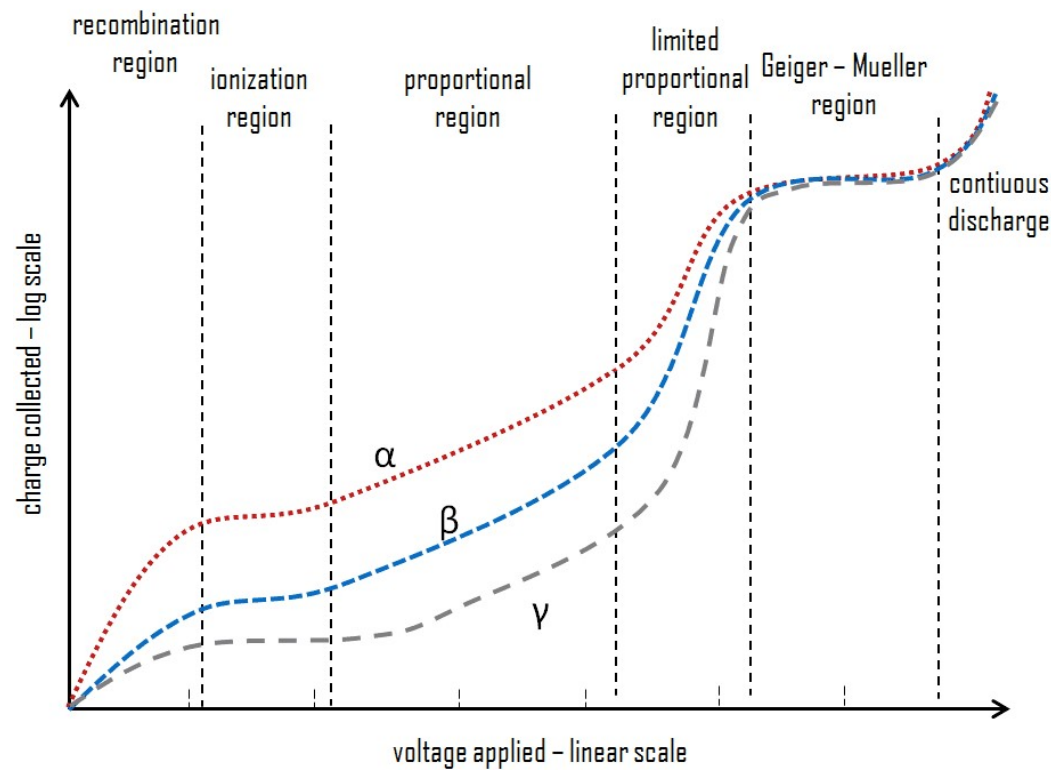
TLD chips and reader



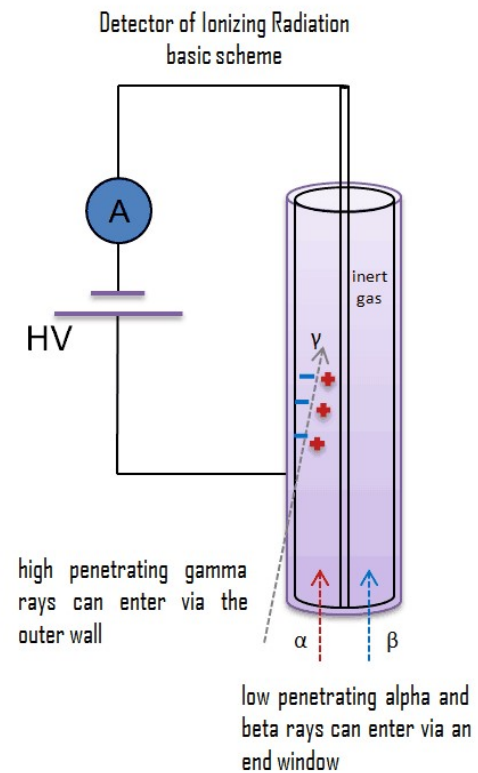
Landauer OSL nanoDot and mircoSTARii reader

Gas filled detectors – regions of operation

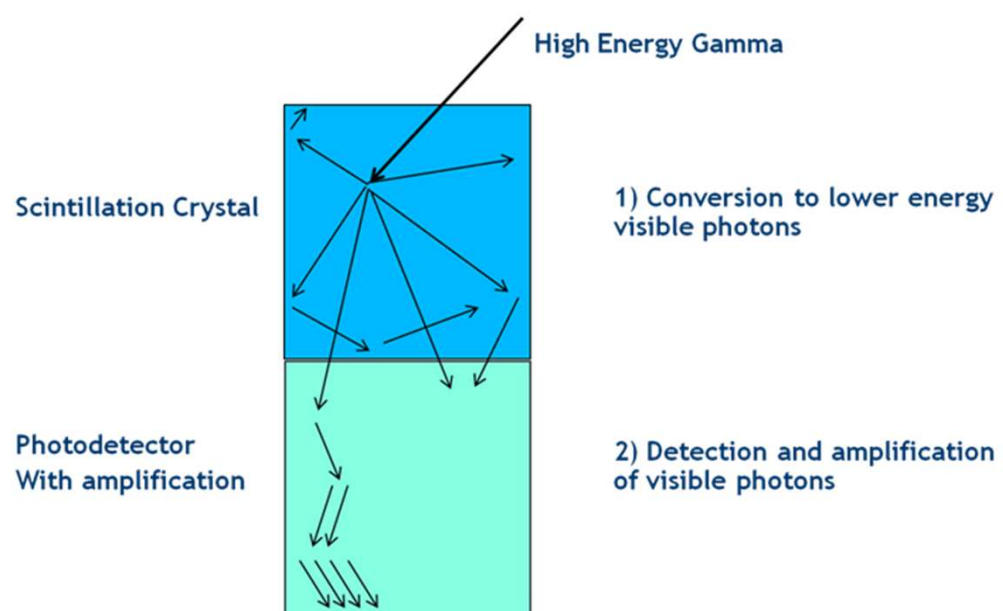
Regions of Gaseous Ionization Detectors



www.nuclear-power.net



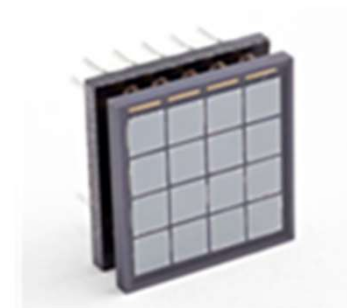
Scintillator based detectors



Scintillator detection technology



PhotoMultiplier Tube



Silicon PhotoMultiplier

Two Mirion products with solid state detectors

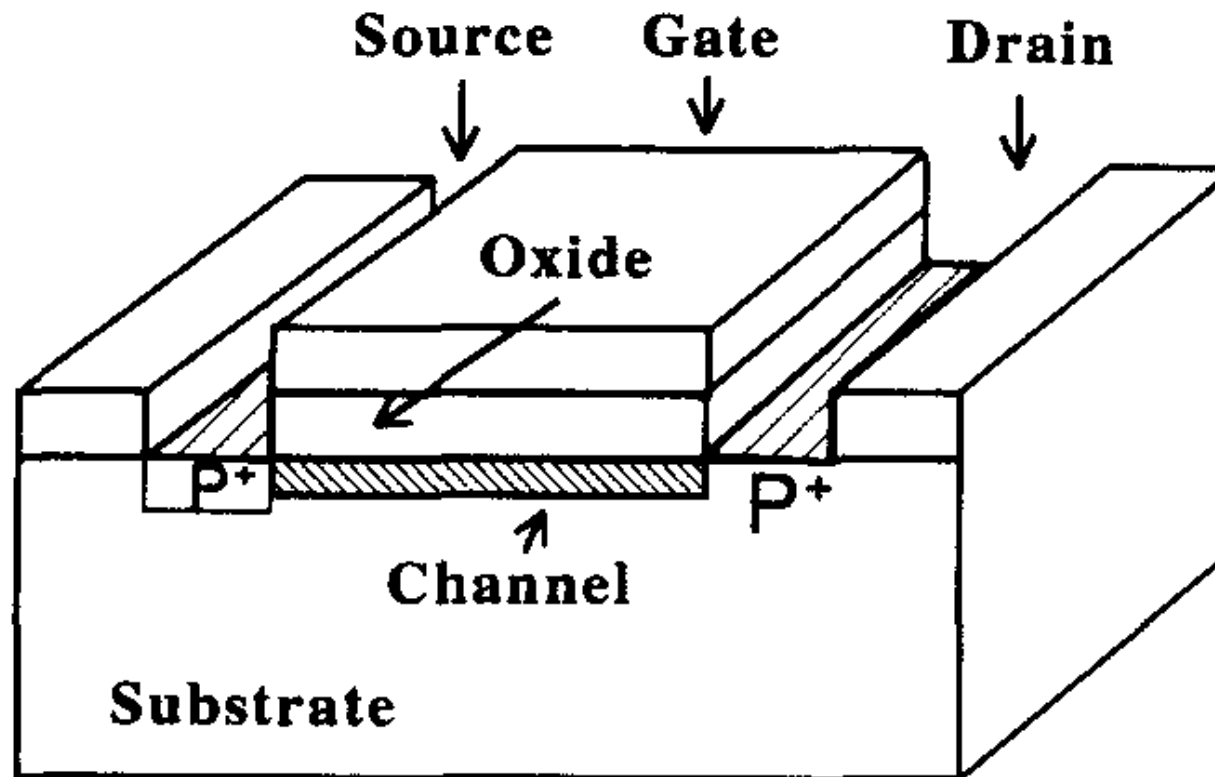


MBD- 2 (contains DIS, MOSFET)

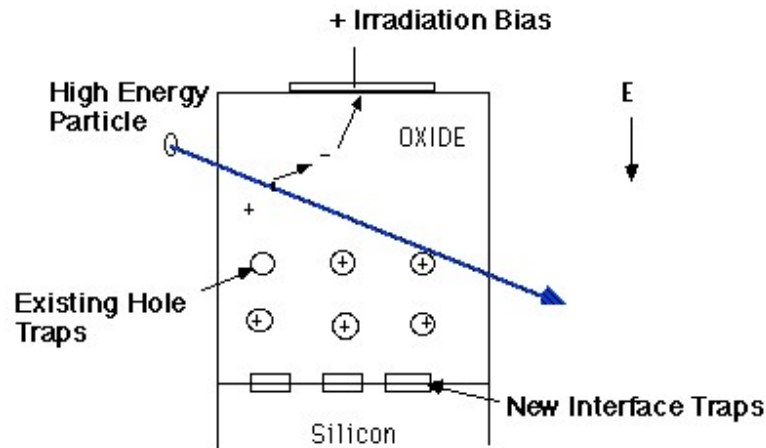


DMC-3000 (contains multiple diodes)

RADFET – What is it?

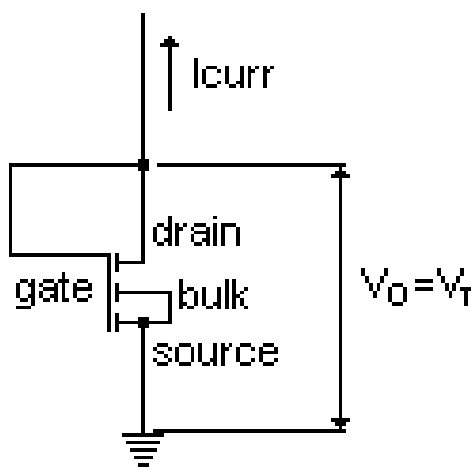


RADFET – Operating principle

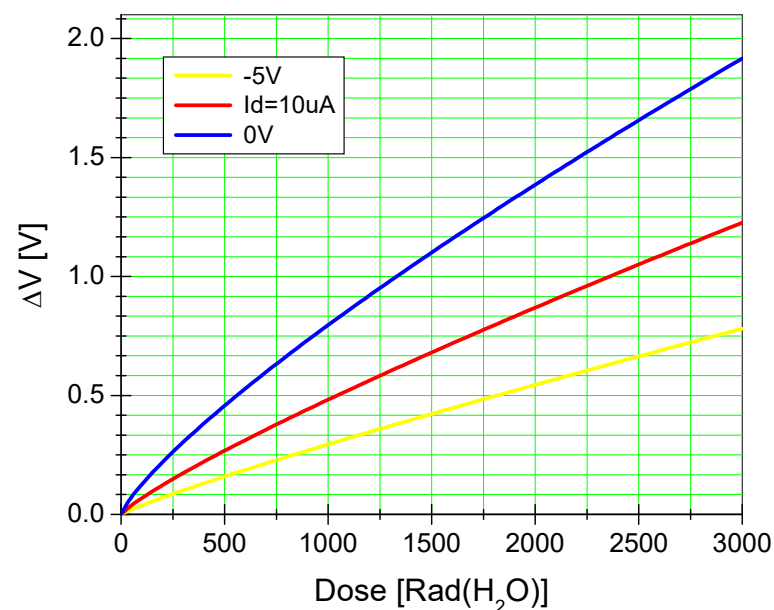


- Radiation creates electron-hole pairs
- Initial recombination of electrons and holes happens
- Non-recombined electrons leave the oxide; holes are trapped in the vicinity of the oxide/silicon interface
- RADFET threshold voltage (V_T) changes ($\Delta V_T \sim \text{Dose}$)

RADFET – Read-out circuit and calibration curves



RADFET read-out circuit

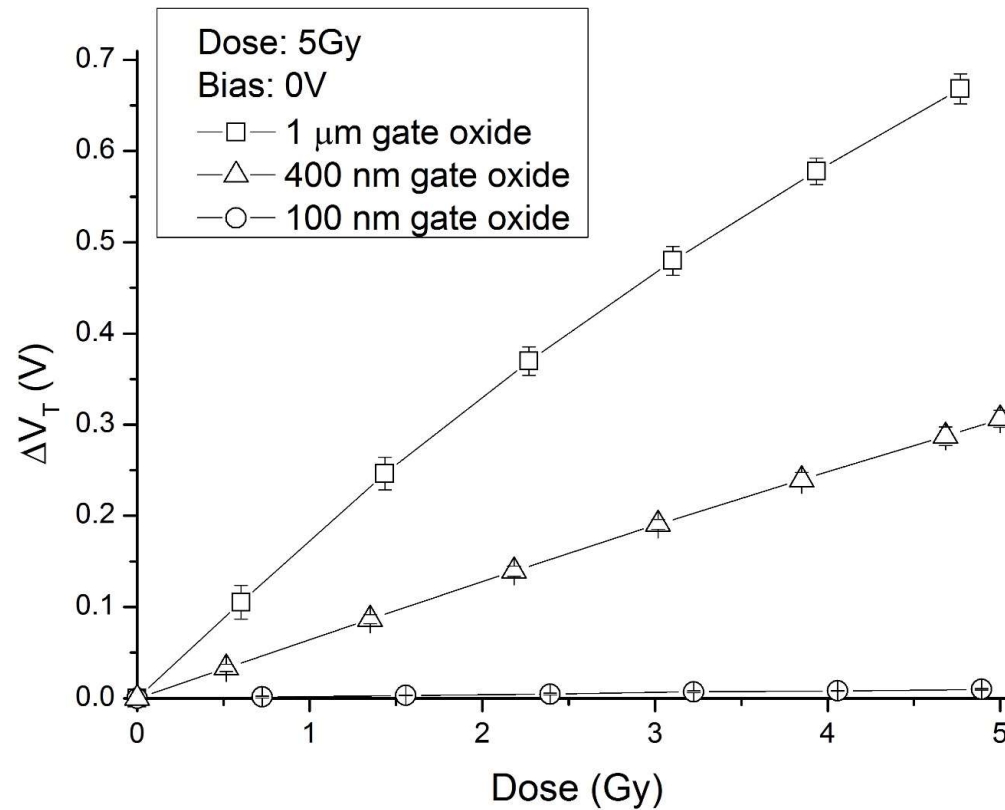


Calibration coefficients

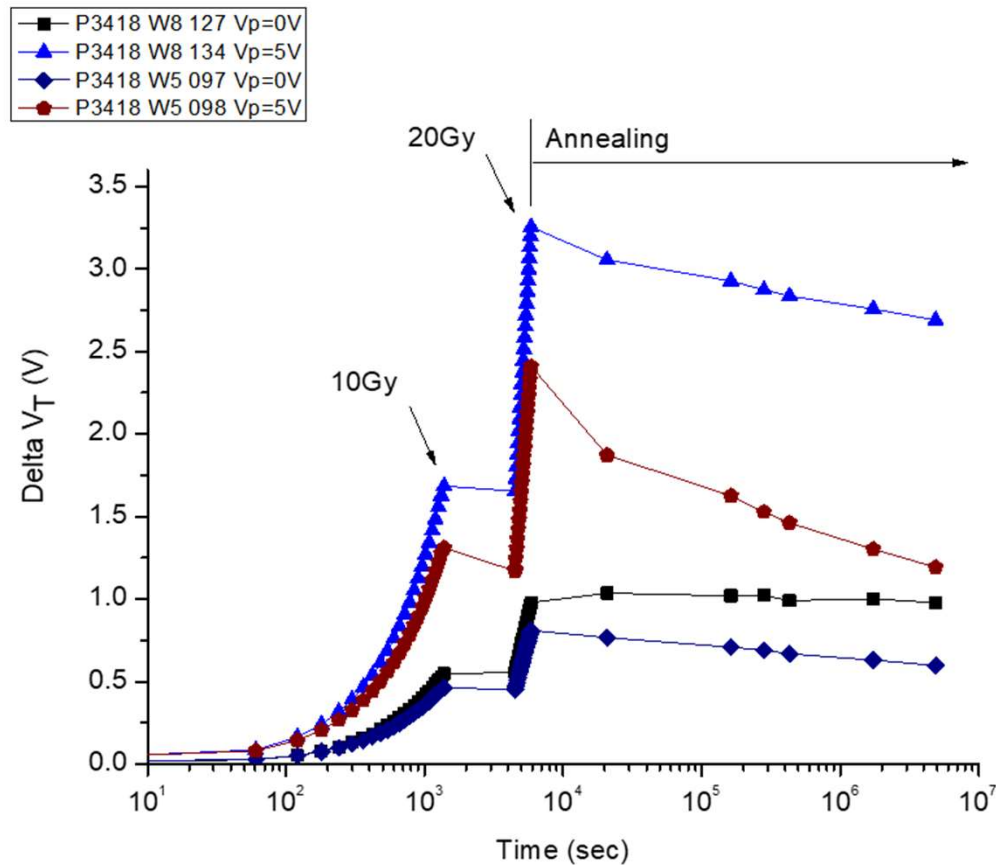
The curve equation is of the form: $\Delta V = a \times \text{Dose}^b$; ΔV [Volts], Dose[Rad(H_2O)].

Bias	a	b	R-square	SSE
-5V	0.000643	0.8871	0.9999	0.00042
Cont $I_d = 10\mu\text{A}$	0.001365	0.8494	0.9994	0.00475
0V	0.003166	0.8001	0.9976	0.04626

RADFET – Effect of gate oxide thickness



RADFET – Sensitivity and fading



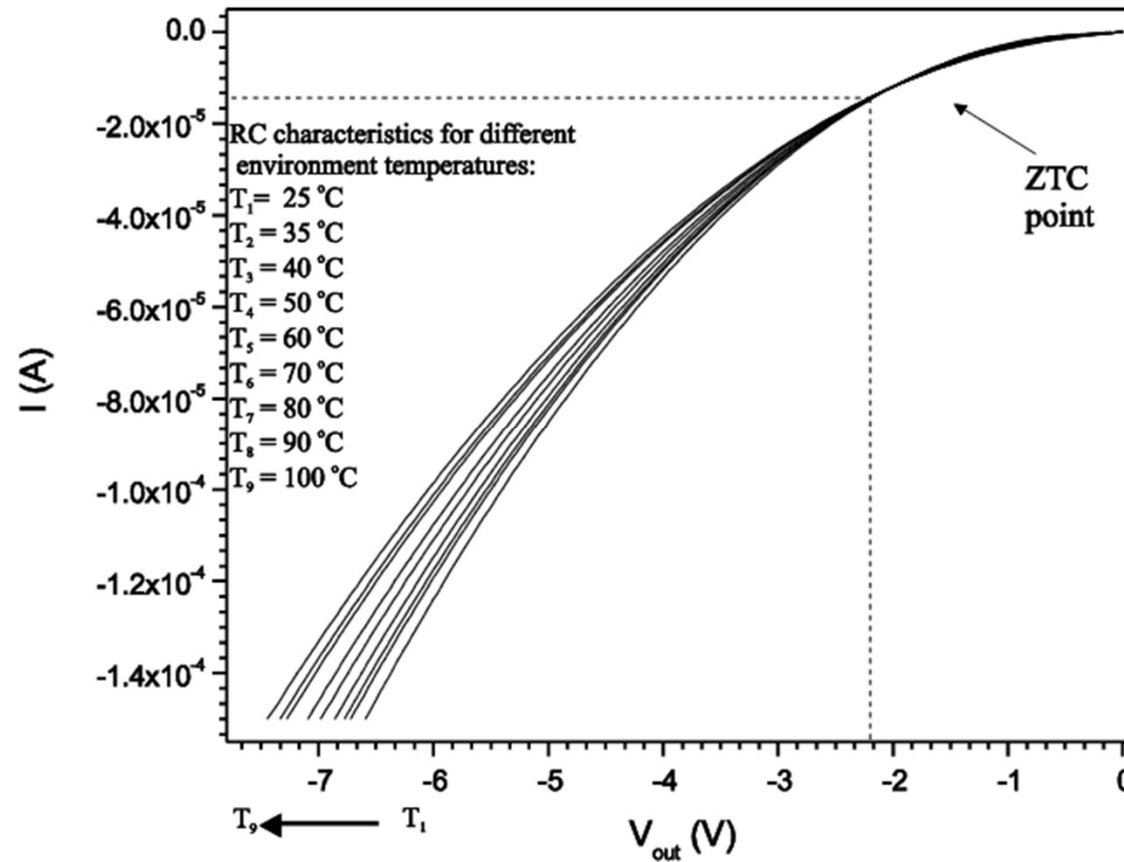
+5V bias:

Part type	Sensitivity [mV/cGy]	Fading [%]
P3418-W8	1.625	17.2
P3418-W5	1.205	50.1

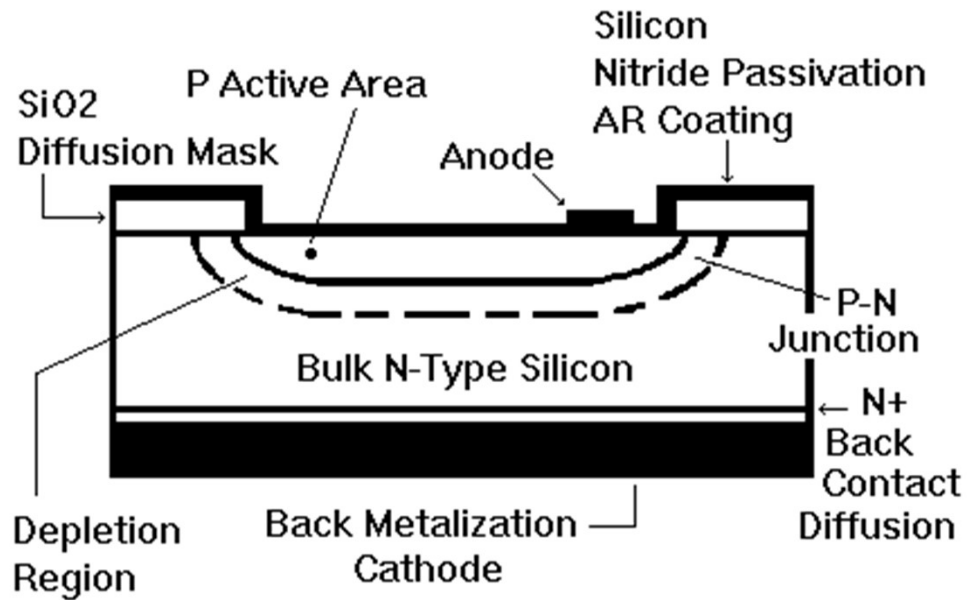
Zero bias:

Part type	Sensitivity [mV/cGy]	Fading [%]
P3418-W8	0.489	0.2
P3418-W5	0.405	27.8

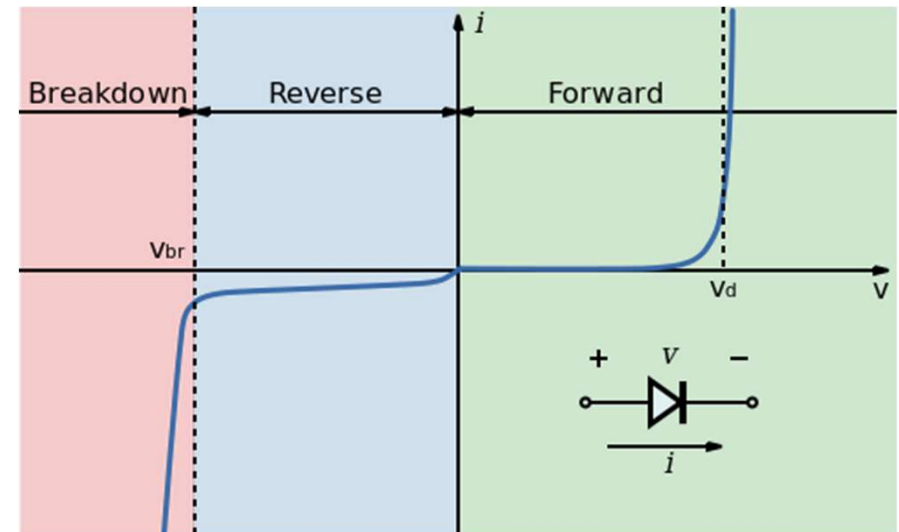
RADFET – Temperature dependence



PIN diode – Cross section and IV curve

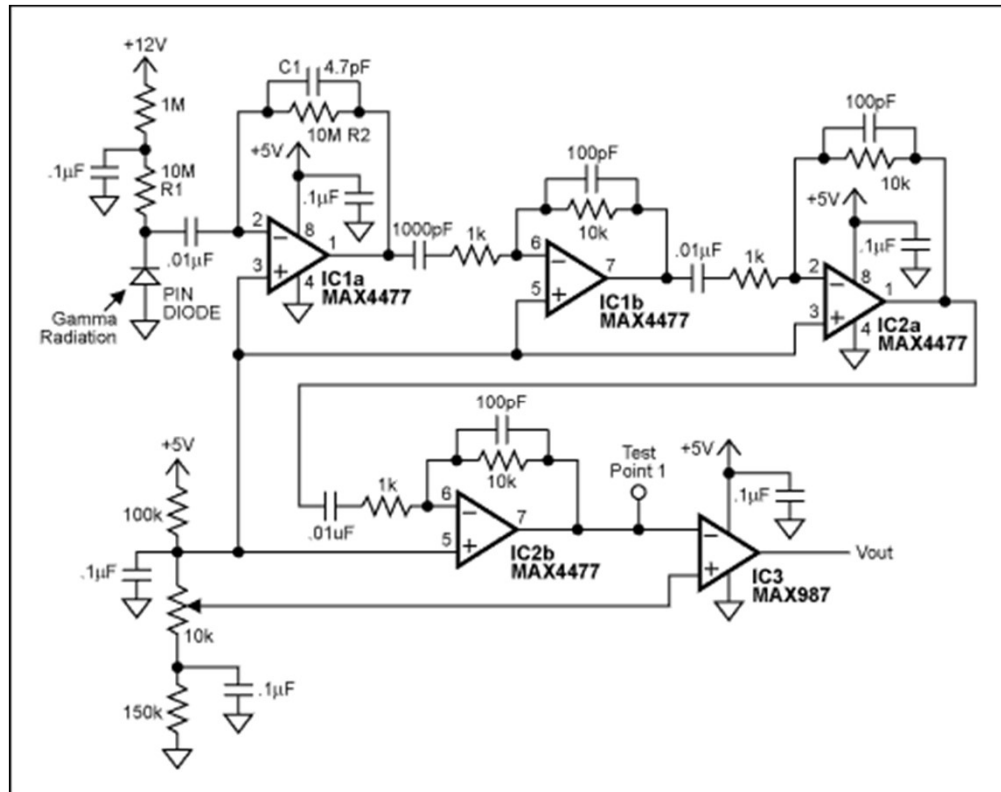


Cross section (N-type region is close to intrinsic)

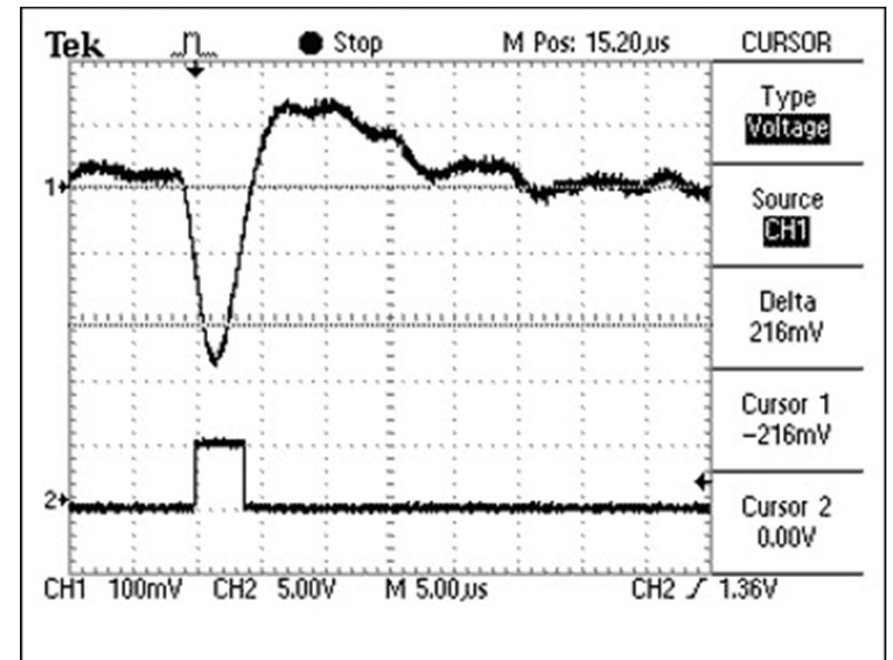


IV curve

PIN diode – Read-out circuit and pulse



Diode read-out circuit



Oscilloscope traces at Test Point 1 and Vout