Silicon-based radiation sensors and dosimeters for security and CBRNE applications

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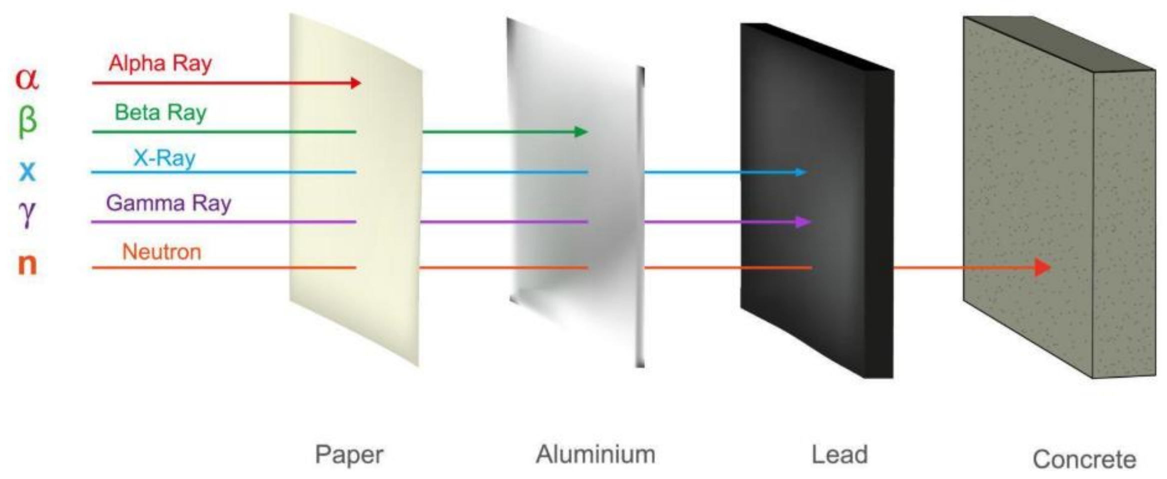
MOTIVATION

The ARGUS Project

- Compact and versatile β, γ and neutron detector system
- Simultaneous detection and identification
- Targets: nuclear safety, environmental monitoring, fundamental research

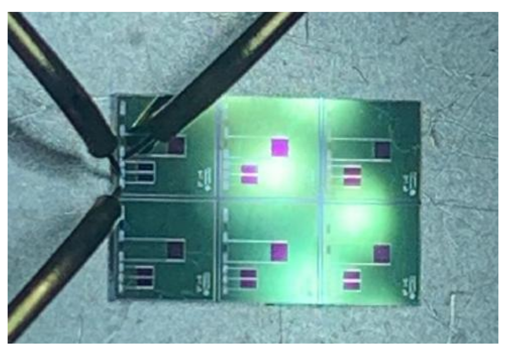


Current status: Project in launching phase. Ongoing work focuses on building the detector expertise and characterization tools that will underpin ARGUS.

WORK LINE 1

HfO_2-based RadFETs

- HfO_2-gate RadFETs (Radiation Sensitive Field Effect Transistor): high sensitivity & CMOS compatible
- IZTC (Zero Temperature Coefficient) bias point → stable operation point, temperature-independent readout



→ALD 50 nm HfO_2
→L= 10 µm
→W= 500 µm
→Vth= -4,48 V

FIGURE 1 — Picture of the RADFET fabricated at IMB-CNM being measured at the probe station and specifications of the device.

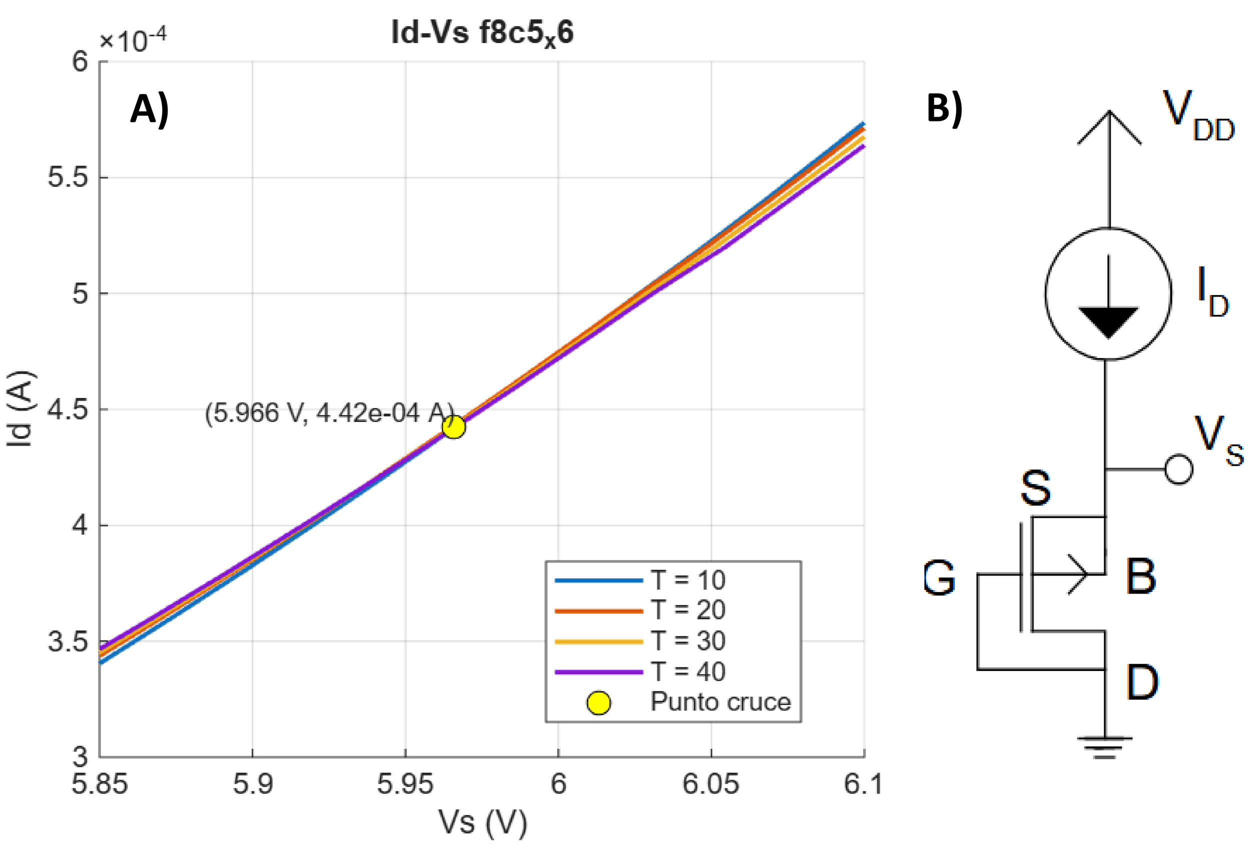


FIGURE 2 —(A) Id–Vs transfer characteristics of an HfO_2-gate RadFET Drain current I_d as a function of voltage V_s for a high-κ (HfO_2) RadFET measured at different temperatures (T = 10–40 °C). (B) Schematic of the measurement set up

WORK LINE 2

Floating-Gate Sensor Mask Design

- **Non-volatile** charge storage mechanism
- Suitable for cumulative dose measurement
- Based on **charge trapping** in the floating gate
- Threshold voltage shifts proportionally to absorbed dose

A complete **photolithography mask set** has been designed for fabrication:

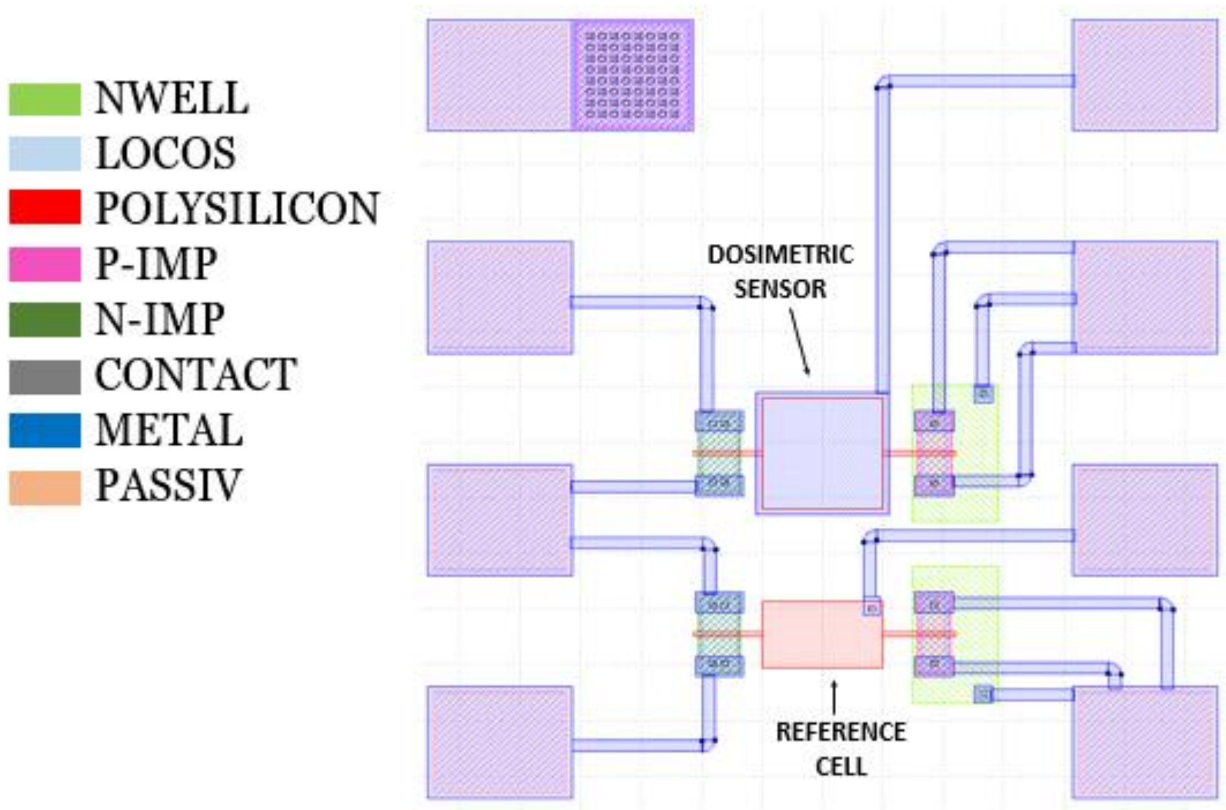


FIGURE 3 —Complete photolithography mask set designed for fabrication of the floating-gate dosimeter, with process layers colour-coded (NWELL, LOCOS, POLYSILICON, P-IMP, N-IMP, CONTACT, METAL, PASSIV) and the dosimetric and reference cells identified.

CONCLUSIONS AND FUTURE WORK

Building towards ARGUS

The three lines of ongoing work provide complementary expertise in device physics, sensor fabrication, and detector characterization that will directly feed into the ARGUS project:

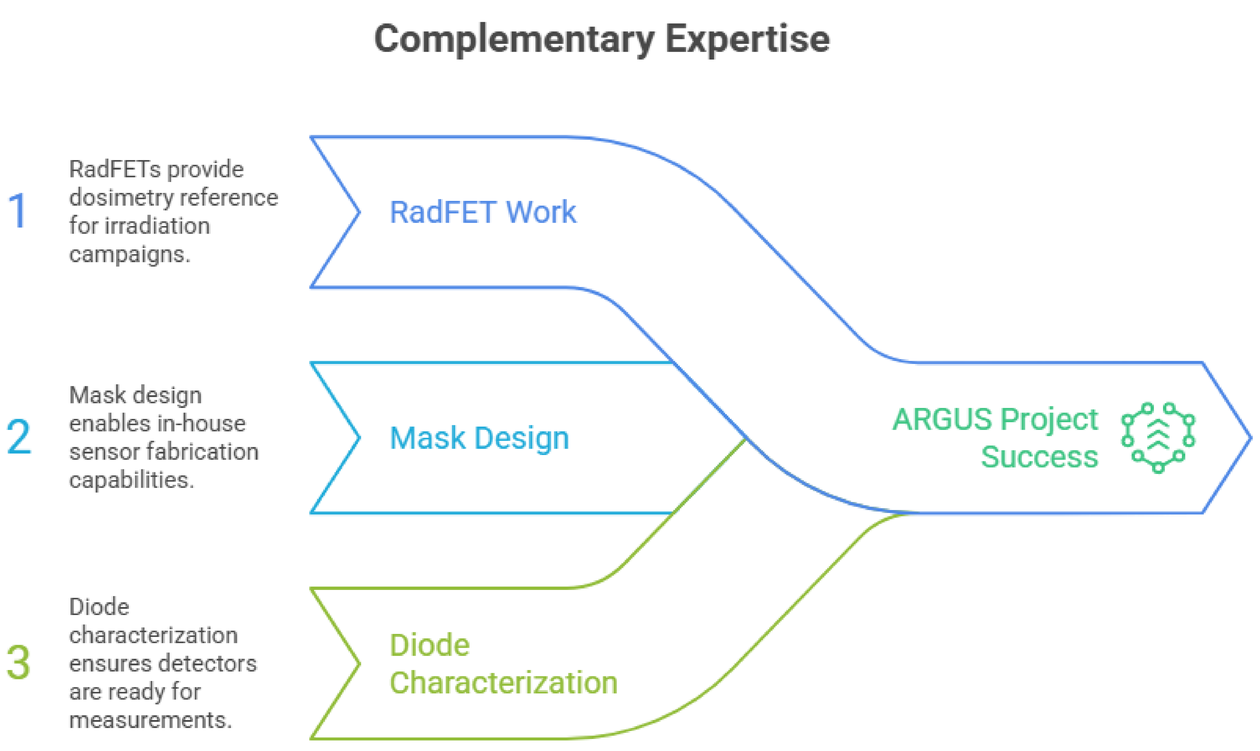


FIGURE 7 —Conceptual diagram illustrating how the three work lines provide complementary expertise that feeds directly into the development of the ARGUS project.

WORK LINE 3

pn Diode characterization for Alpha Detection

Simulation of alpha particle transport through the detector layer stack was studied using two complementary approaches:

- **SRIM**: ion trajectories and vacancy production profiles in the Si stack
- **Custom Monte Carlo (Python)**: energy deposition and detected spectra

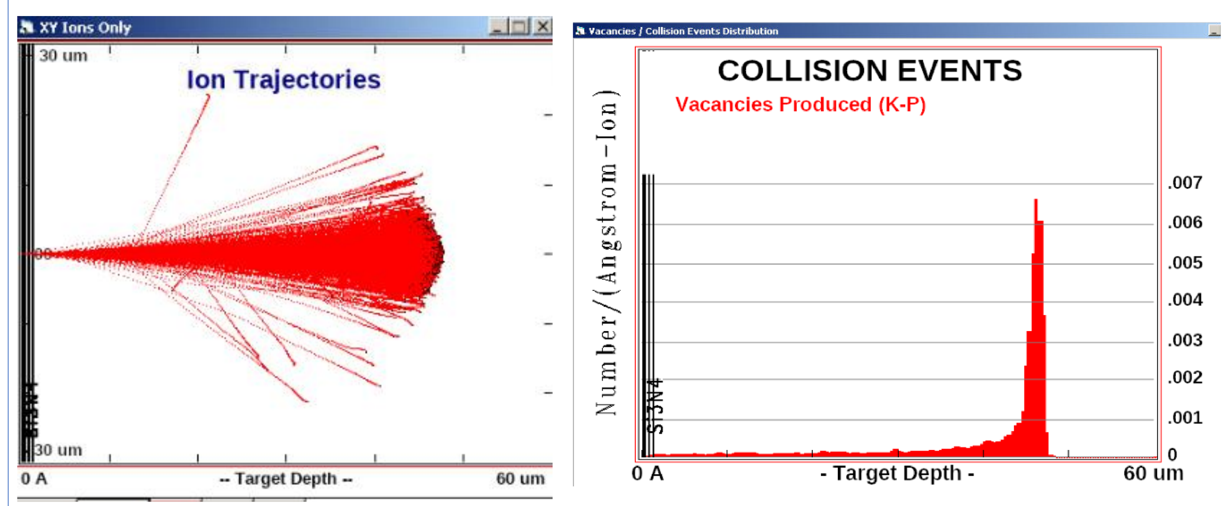


FIGURE 4 —SRIM simulation of alpha particle trajectories in silicon

Reverse I–V and C–V measurements of IMB-CNM pn diodes were done to assess leakage current, breakdown, and full depletion voltage (Vfd).

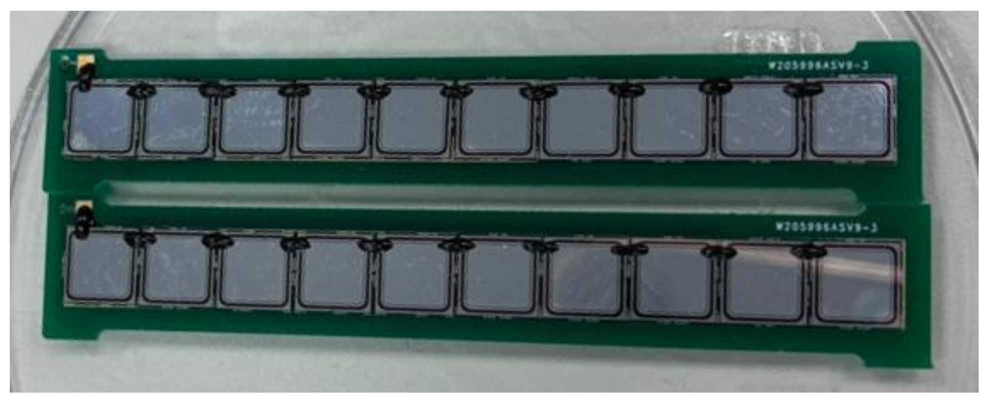


FIGURE 5 —Photograph of pn diodes fabricated at IMB-CNM

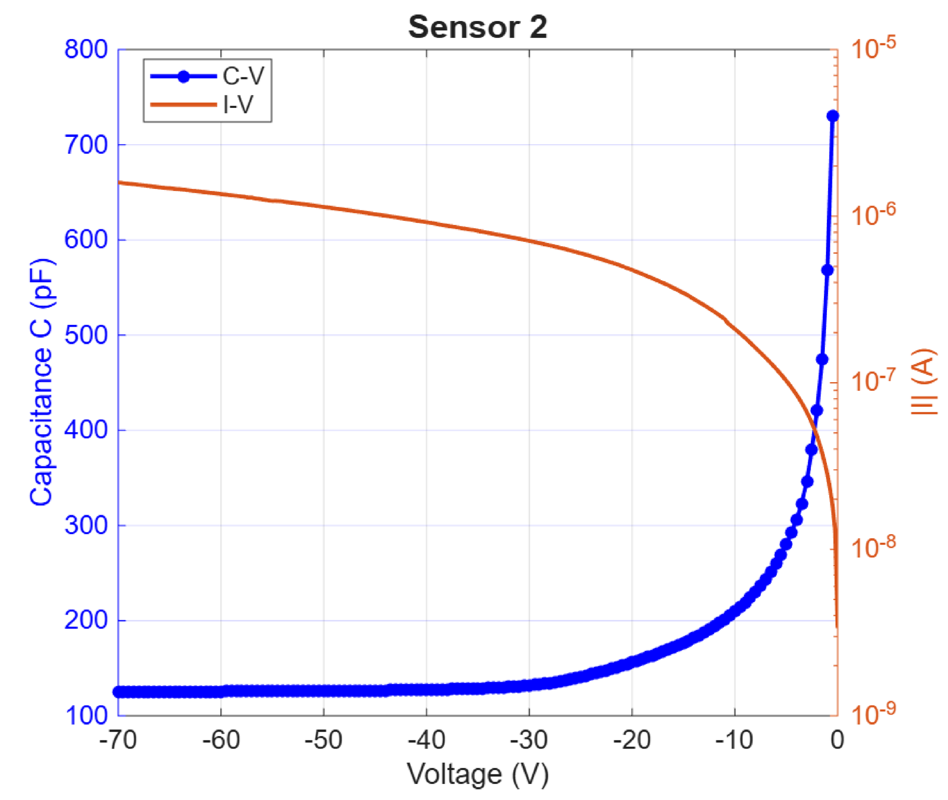


FIGURE 6 —Electrical characterization of Sensor 2: reverse I–V curve (red) and C–V curve (blue) used to determine the full depletion voltage V_{fd} of the pn diode.

Next step: Alpha particle measurements with a triple-alpha source (^{241}Am / ^{239}Pu / ^{244}Cm) to observe pulse shapes and assess detection efficiency.

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