Electrical Characterization, Parameter Extraction, and Radiation Response of aSi:H and Crystalline Silicon Photodiodes

Ali Khalilzadeh[1,*], Khalil El Achi[1], Alexis Warnier[2], Victor De Beco[2], Séverine Rossomme[2], Laurent A. Francis[1], Denis Flandre[1]

[1.]Electrical Engineering Department, ICTEAM Institute, UCLouvain, 1348. [2.] Ion Beam Applications (iba), 1348 Louvain-la-Neuve, Belgium.

* Corresponding author, Ali.Khalilzadeh@UCLouvain.be

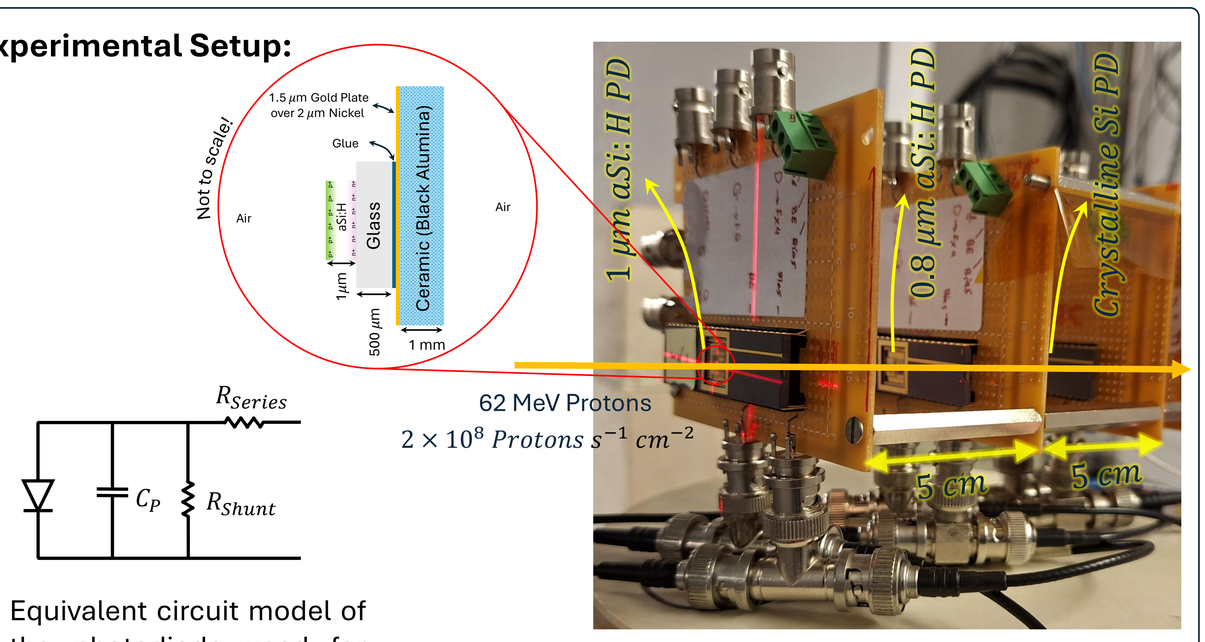
Motivation:

- Proton therapy QA requires accurate beam monitoring.
- Semiconductor photodiodes are attractive candidates for beam position monitoring.
- Proton irradiation can alter detector electrical characteristics and degrade performance.
- This work compares aSi:H in two different thickness and crystalline Si photodiodes by extracting equivalent-circuit parameters from I-V and C-V measurements [1] before irradiation, following irradiation at three dose levels, and after post-irradiation annealing.

Objectives:

- Extract equivalent-circuit parameters from I-V and C-V measurements.
- Evaluate parameter stability under proton irradiation.
- Compare the electrical performance of aSi:H and crystalline Si photodiodes.

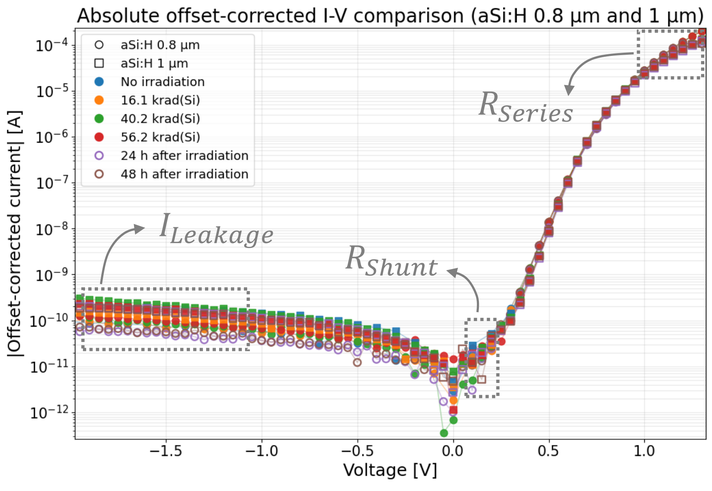
Experimental Setup:

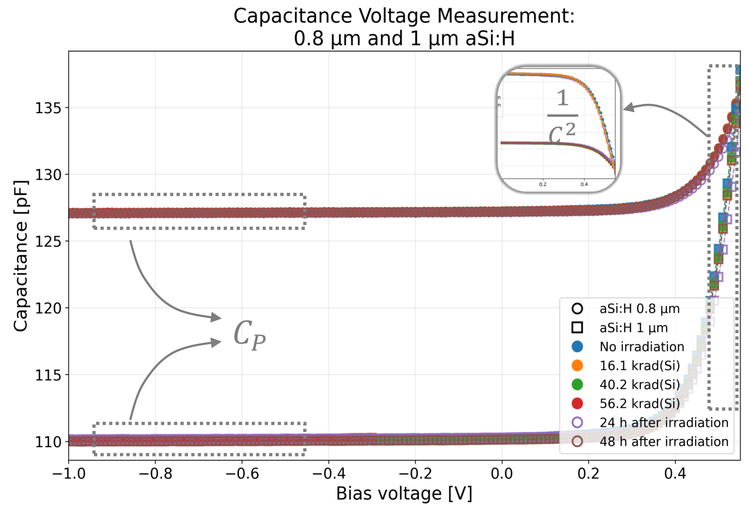


Equivalent circuit model of the photodiode used for electrical characterization.

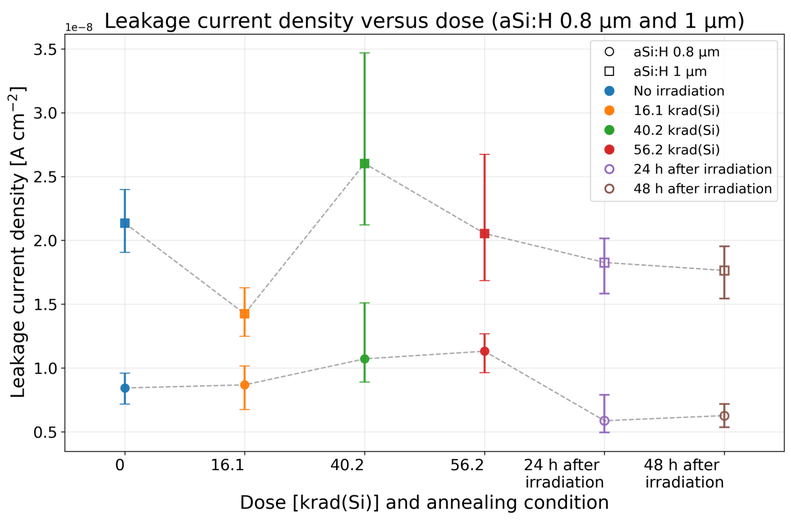
Experimental setup for proton irradiation and electrical characterization at the UCLouvain Cyclotron.

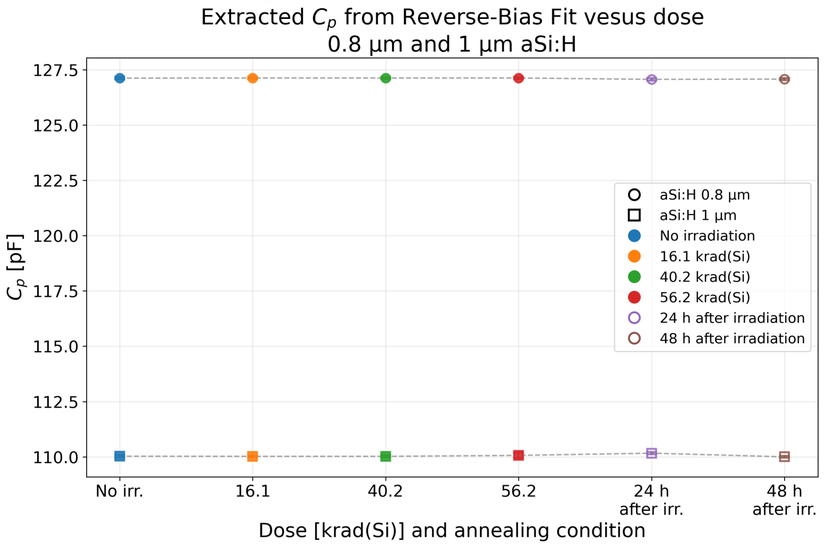
Measured IV and CV of aSi:H:

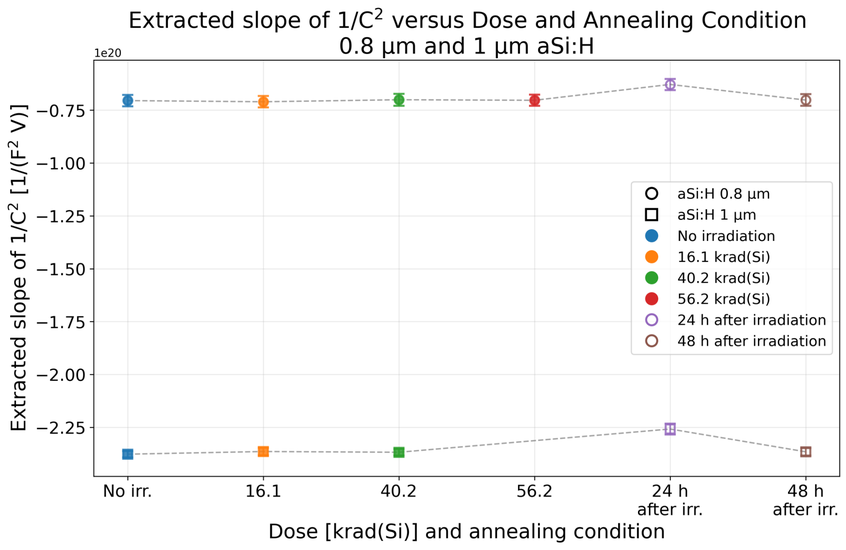




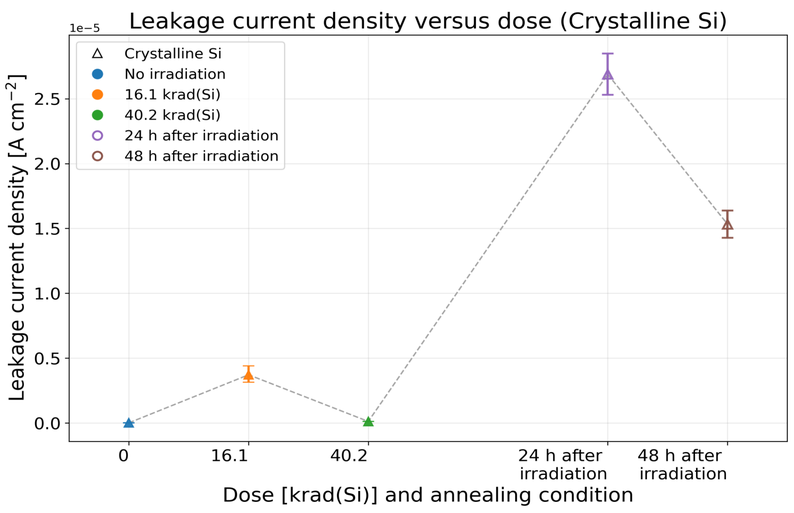
Extracted $I_{Leakage}$ density, C_P and $\frac{1}{C^2}$ versus irradiation and annealing for aSi:H:

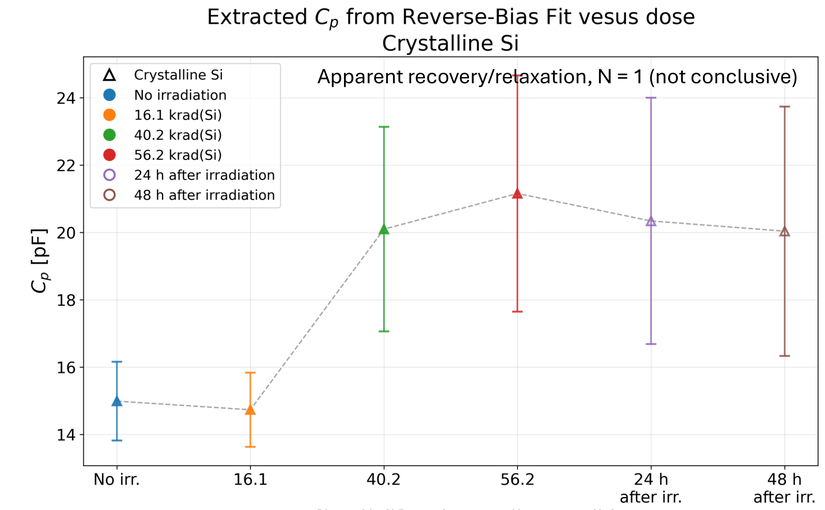


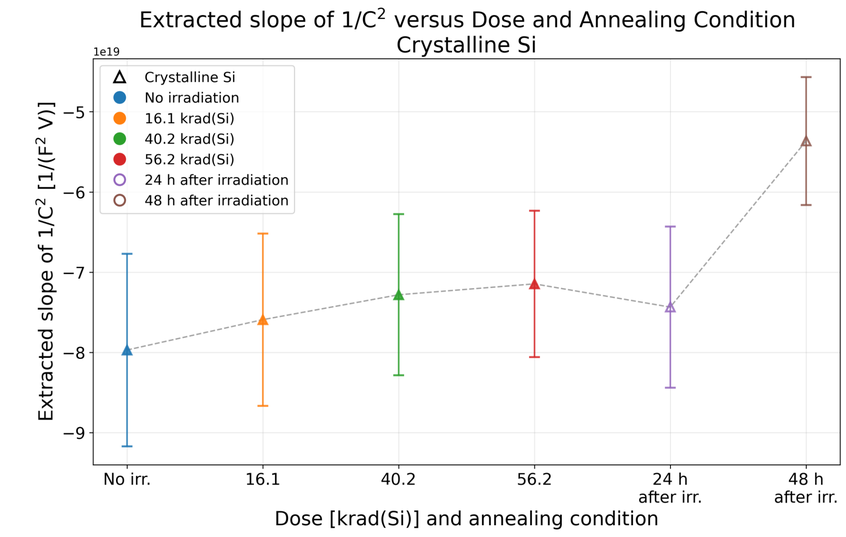




Extracted $I_{Leakage}$ density, C_P and $\frac{1}{C^2}$ versus irradiation and annealing for crystalline Si:







Conclusion:

- The aSi:H detectors (0.8 and 1μm) showed only minor changes in leakage current density with irradiation, recovering close to their initial values after 24-48 hours annealing. In contrast, the crystalline Si photodiode shows a leakage current approximately three orders of magnitude higher.
- aSi:H shows much stronger capacitance stability under irradiation, the capacitance changes by <0.2% in both 0.8 μm and 1 μm aSi:H sample, while crystalline Si shows ~40% increase in C_P after irradiation and only partial relaxation after 24-48 hours.
- The $\frac{1}{C^2}$ slope response suggests that extracted effective charge density remains approximately unchanged in aSi:H after irradiation, while crystalline Si shows stronger evidence of radiation-induced modification in defect-related effective charge density.
- The structure of aSi:H reduces its sensitivity to radiation-induced damage compared with crystalline silicon. These results indicate that aSi:H is a promising candidate for radiation-hard detectors in proton beam monitoring applications.

Acknowledgment:

This work was supported by the Walloon Region under the PSQUAD project. The authors also gratefully acknowledge the support of the WELCOME Laboratory

[1] S. K. Cheung and N. W. Cheung, "Extraction of Schottky diode parameters from forward current–voltage characteristics," Applied Physics Letters, vol. 49, no. 2, pp. 85–87, Jul. 1986. doi:10.1063/1.97359.

27^{th} **International Workshop on Radiation Imaging Detectors** (June 28 to July 2, 2026, Ghent, Belgium)