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#9-307 Design of a new 2D amorphous Silicon-based detector for Particle Therapy

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Proton and Radiotherapy are leading particle therapy tactics used to combat chronic and malignant cancers [1]. Ultrahigh dose rate (UHDR) flash therapy, is a new treatment modality that is currently being studied by several groups. The treatment delivers high doses in a short period of time (40 Gy/s) and is highly effective against tumor cells while maintaining healthy cells. Moreover, particle therapy also has radiobiological advantages compared to conventional therapy [2]. UHDR dosimetry presents a crucial challenge to detectors when performing proper quality assurance (QA) measurements.

This work aims to develop a high-resolution 2D solid-state detector for accurate QA clinical routine in particle therapy. Amongst semiconductor materials, amorphous silicon (aSi) is characterized by durable radiation hardness [3], thus it is a notable candidate for material to build the active region of a solid-state detector.

To build a solid-state-based detector that can handle a wide range of doses and dose rates delivered by particle beams, the following solution is thus investigated. The active region will comprise a p-n junction that is composed of a lightly p-doped bulk aSi (Np $\approx 10^{15}\text{cm}^{-3}$) and highly n-doped implants (Nn $\approx 10^{18}\text{cm}^{-3}$), represented in Figure 1a. At this unbiased state, the detector can withstand large charges generated with flash measurement. At lower doses, a reverse bias voltage would be applied up to Vrb = 5V to fully deplete the detector and expand the active region to ≈ 2µm, to grant a decent signal-to-noise ratio (SNR). Monte Carlo simulation [4] will be used to compute the response of the active region, pertaining to the different beam modalities. In addition, COMSOL Multiphysics will be used to characterize and design the photodiode with the coupled thin-film transistor (TFT).

Early irradiation measurements using the IBA Razor diode performed at different proton beam intensities were done at UCLouvain cyclotron to validate simulation accuracy. The measured values using an IBA DoseX electrometer show pristine charge linearity and close correlation with the simulation estimation where the measurement falls in between the 2σ approximation with a 10% offset from the most probable value, shown in Figure 1b. Further tests will be performed in clinical settings using high-energy gamma rays and flash proton intensities for both aSi and cSi-based diodes to understand the different behaviors of both materials and their usability in patient QA.

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