FEASIBILITY STUDY OF USING INNOVATIVE TECHNOLOGY BASED ON SILICON CARBIDE DETECTORS FOR FLASH IRRADIATIONS

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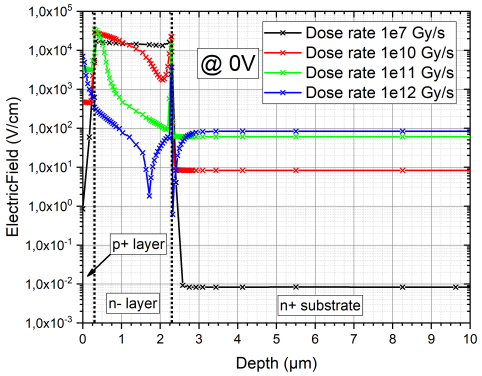
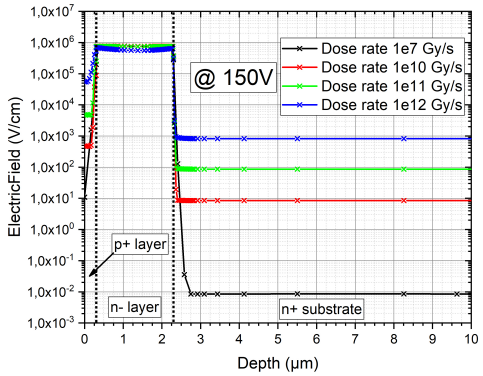
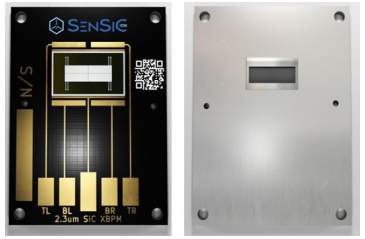
***ABSTRACT**: **Ultra-high dose rate (UHDR)** beams for FLASH radiotherapy present significant **dosimetric challenges**. Ionization chambers are affected by heavy ion recombination issues, although novel approaches for decreasing or correcting for this effect are being proposed. Passive dosimeters, as radiochromic films and alanine, are widely used for UHDR measurements, but dose determination is typically time consuming and thus cannot be used in the perspective of a future clinical translation. **Solid state detectors** have been recently investigated, as a valuable alternative for **real-time measurements**, especially for relative dosimetry and beam monitoring. **Silicon Carbide (SiC)** detectors represent a good compromise between the maturity of silicon detectors and the robustness of diamonds, allowing for large areas and high applied voltages. The response of novel ultra-thin SiC detectors was studied through **simulations** and **experimentally characterized** with low energy UHDR electron beams.*

Simulations





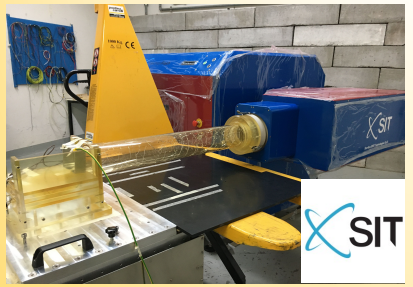
Calculated electric fields (EC) as function of beam flux and external bias. Variations of EC within the n- active region are associated with higher recombination and thus lower charge collection efficiencies (CCE). High external biases (equivalent to 6.3E5 V/cm) are needed to achieve high CCE



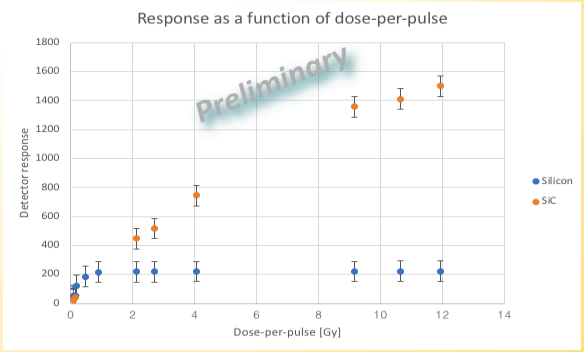
SiC detectors

The device structures used for the realization of a SiC detector from SenSiC company are semiconductor PIN junctions: a thin p+, highly doped layer (0.3um, NA = 1E19cm-3) a n- low doped layer (either 10um or 2um, ND = 8E13cm-3) on top of a n+ thick substrate (370um, ND = 5E18cm-3). In the case of the “free-standing membrane”, the n+ thick substrate was selectively removed by means of electrochemical etching.

- **UHDR e- at 7-9 MeV (SIT-Sordina)**
- **pulse duration: 2-4 us**
- **dose per pulse (D/p): 0.01-12 Gy**



Measurements



Measurements with the electrons at conventional and UHDR regimes have been carried and the response of SiCs was compared with a commercial silicon diode. A characterization of the SiCs was previously done to select the applied voltage for which the produced charge is properly collected (V=480 V). Preliminary results are showed (data analysis in progress). Dose values at the irradiation points for the different D/p configurations were obtained with alanine detectors. As visible from the plot, SiCs have a linear trend up to about 4 Gy/p, differently from the silicon diode, which start saturating at less than 0.5 Gy/p. The slight under-response of Sics at higher D/p is not due the detector saturation itself but to the used electrometer, according to the instantaneous produced current (up to 1 A) and to the related (not sufficient) required power.

***CONCLUSIONS**: A first **feasibility study** of **SiC** detectors at **UHDR beams** was carried out. Simulations of CCE of the device and first measurements with UHDR electrons at 7 and 9 MeV have provided promising results, clearly indicating the feasibility of using SiCs at these extreme regimes. **Systematic investigations** are planned and further **cross-comparisons** with other detectors will be performed in the next future in the framework of the Italian **INFN FRIDA** (FLASH Radiotherapy with hIgh Dose-rate particle beAms) project, with the aim of **establishing** this technology for relative **dosimetry** and real-time **beam monitoring** for FLASH radiotherapy with UHDR beams.*

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