New developments on SiC dosimeters for advanced radiotherapies

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Abstract New radiation therapy modalities require innovative dosimetry solutions. For decades, silicon single crystal has been the most widely used semiconductor substrate material for radiation detectors thanks to the well-established microelectronic production processes. However, in recent years, wide bandgap semiconductors such as silicon carbide (SiC) and diamond are enjoying a rapid growth. In this poster we describe the performance as radiation dosimeters of SiC diodes fabricated at IMB-CNМ-CSIC and present the first SiC microdosimeters.

Why SiC? Wide bandgap semiconductors (SiC and diamond), compared to silicon, have:
• Lower dark currents
• Higher saturation velocity of charge carriers
• Higher thermal conductivity
• Higher radiation hardness, insensitivity to light and tolerance to temperature variations
• Better tissue equivalence

In addition, SiC compared to diamond has:
• More mature technology allowing to produce complex structures
• High quality substrate material available up to 6” wafers at a reasonable cost: good price-performance ratio

Devices and tests Devices are p-n junction circular diodes with 1 mm diameter fabricated on a 4H-SiC substrate with a 50 μm thick n-type epilayer doped at 1.5×10¹⁴ cm⁻³ [1,2]. They have been irradiated with low energy 50kV X-ray radiation and in a 9MeV electron beam from a Varian Clinac 2100 accelerator.

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References
3. C. Fleta et al. (2015), doi:10.1088/1748-0221/10/1/P10001
4. C. Guardiola et al. (2021), doi:10.1088/1361-6560/abl811

Results
50kV X-rays, 0 V bias

- Linearity deviation with 50 kV X-rays integrated dose delivered is less than 1.5%
- Medium-term stability with integrated dose up to 18 kGy X-rays is better than 0.3%
- Linearity deviation with dose per pulse of 9 MeV electrons up to 2.5 mGy is less than 1.5%

9 MeV electrons, 40 V bias, ref.: PPC40 @ -400 V

SiC diodes show good performance as dosimeters in conventional RT beams where they are a promising alternative to other semiconductor materials. Further tests will be performed to evaluate their capabilities in UHDR beams.

Future: new SiC microdosimeters
• We have fabricated the first SiC microdosimeters with ~μm³ sensitive volumes (spatial and energy resolution) and a multi-channel design (allowing for 2D beam mapping).
• Based on our experience with micromachined silicon micro-dosimeters for hadrontherapy that have been used to measure microdosimetric distributions at therapeutic-equivalent fluence rates [3,4].