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-CNM-CSIC and present the first SiC microdosimeters.

Why SiC?

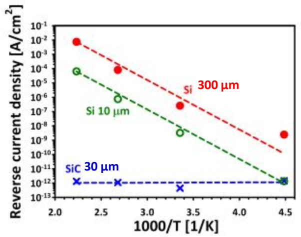
Wide bandgap semiconductors (SiC and diamond), compared to silicon, have:

- 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

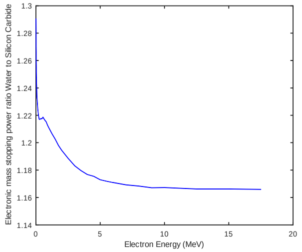
In addition, SiC compared to diamond has:

- 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**

Current-Temperature dependence [1]



Electronic mass stopping power (ESTAR)



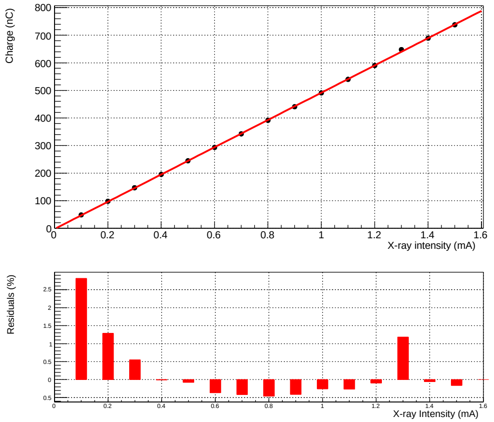
Devices and tests

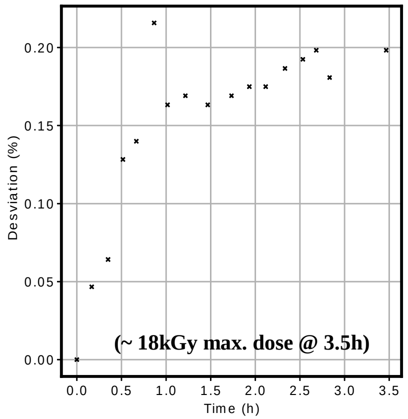
Devices are p-n junction circular diodes with 1 mm diameter fabricated on a 4H-SiC substrate with a 50 µm thick n-type epilayer doped at 1.5×10^{14} cm^{-3} [1,2].

They have been irradiated with low energy **50kV X-ray** radiation and in a **9MeV electron beam** from a Varian Clinac 2100 accelerator.

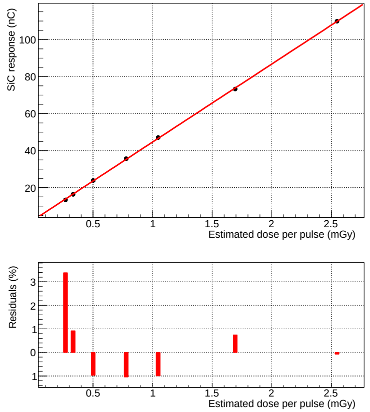
Results

50kV X-rays, 0 V bias





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

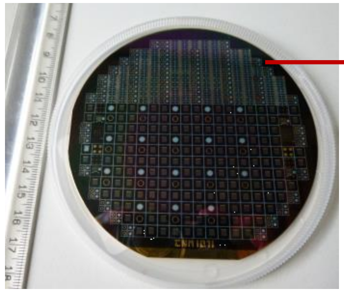


- ✓ Linearity deviation with 50 kV X-rays integrated dose delivered is less than 1.5%
- ✓ Medium-term stability with integrated dose up to 18 kGy X-rays is better than 0.3%
- ✓ Linearity deviation with dose per pulse of 9 MeV electrons up to 2.5 mGy is less than 1.5%

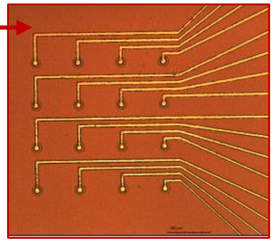
SiC diodes show **good performance as dosimeters in conventional RT beams** where they are a promising alternative to other semiconductor materials. Further tests will be performed to evaluate their capabilities in UHDR beams.

Future: new SiC microdosimeters

- We have fabricated the first SiC microdiodes with ~µm^3 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].



SiC microdiodes wafer and detail



References

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3. C. Fleta et al. (2015), doi:10.1088/1748-0221/10/10/P10001
4. C. Guardiola et al. (2021), doi:10.1088/1361-6560/abf811

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