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Silicon Carbide Detectors for Future Colliders and Medical Applications

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Silicon carbide (SiC), a wide bandgap semiconductor, has many excellent material properties that make it an attractive candidate for particle detectors. Thanks to widespread usage in the power electronics industry, SiC processing has undergone significant quality improvements in the last ten years, with a reduction in price and an increase in wafer sizes. At the same time, particle physics experiments at colliders have increased their radiation hardness requirements, now demanding detectors to perform up to fluences of $10^{17}\mathrm{n_{eq.}/cm^2}$. For silicon detectors, the leakage current increases and charge collection efficiency decreases rapidly above $10^{15}\mathrm{n_{eq.}/cm^2}$, resulting in a large power draw that needs to be cooled. This has re-catalyzed the search for alternative semiconductor materials. Diamond detectors have been investigated with promising results, but the cost of the material prohibits large-scale ($> 1\mathrm{m}^2$) applications. Silicon carbide combines the advantageous material properties of wide band gap semiconductors with the processing technology and low cost of silicon.

We present the current status of R&D at HEPHY towards radiation-hard SiC timing detectors for future colliders and medical applications. We investigated the radiation hardness of SiC as a material and found a negligible increase of the leakage current for fluences up to $10^{18}\mathrm{n_{eq.}/cm^2}$, allowing for room-temperature operation after irradiation.
To leverage the fast charge carrier velocities, we are developing SiC low-gain avalanche diodes (SiC-LGADs) that could surpass the timing performance of silicon LGADs in the future, mitigating the increased pileup at increased luminosities.

In addition to HEP applications, we also develop SiC detectors for clinical applications.
Two applications will be presented: First, we have developed time-resolved SiC dosimeters for ultra-high dose rate ion beams at MedAustron. High dose rates (>40 Gy/s) allow the FLASH effect to be leveraged, widening the treatment window and improving patient outcomes. Second, we are developing next-generation SiC microdosimeters, which not only measure the dose but the radiation quality as well, which can be used to quantify the biological impact of the delivered dose.

Authors: GSPONER, Andreas (Austrian Academy of Sciences (AT)); BURIN, Jürgen (Austrian Academy of Sciences (AT)); KNOPF, Matthias; GAGGL, Philipp (Austrian Academy of Sciences (AT)); WAID, Simon Emanuel (Austrian Academy of Sciences (AT)); GUNDACKER, Stefan (Austrian Academy of Sciences (AT)); BERGAUER, Thomas (Austrian Academy of Sciences (AT)); KAUSEL, Matthias (MedAustron, TU Wien); ONDER, Sebastian (Austrian Academy of Sciences (AT))

Presenter: GSPONER, Andreas (Austrian Academy of Sciences (AT))

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