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Investigating the Timing Performance of Silicon Carbide Particle Detectors using Simulations

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Silicon Carbide (SiC) features a ten times higher breakdown field and nearly twice the charge carrier saturation velocity than silicon, theoretically enabling faster signal formation and improved timing resolution. The current road towards designing SiC-LGADs has the potential of unlocking ultra-fast timing detectors, with potentially improved radiation hardness over silicon-based LGADs. However, past research on the timing performance of SiC detectors is scarce, as planar sensors without internal gain struggle to detect minimum ionizing particles with a sufficient signal-to-noise ratio. We report our recent advancements in probing SiC timing performance and designing fast SiC timing detectors using AllPix² simulations.
We employed AllPix² to investigate the theoretical limits of the timing resolution of planar SiC detectors due to Landau fluctuations. By comparing the results to simulations with silicon and diamond, we found that at their respective saturation velocities, SiC exhibits the highest signal power density above 1 GHz, theoretically enabling the best time resolution among the three materials.
However, to access the full spectrum, fast readout electronics are needed. We developed a high-bandwidth readout board based on a monolithic microwave integrated circuit with an intrinsic bandwidth of 10 GHz and 50 Ω input impedance. Coupled with a planar SiC diode with 1 pF capacitance, we achieved a signal bandwidth of 5.5 GHz, which allows us to resolve the charge carrier drift at reverse biases up to 1100 V. To verify our measurement results, we developed an end-to-end simulation workflow integrating TCAD device simulations into AllPix² for accurate current signal modeling, followed by electronics simulations in QUCS-S. We plan to apply this workflow to evaluate the timing performance of SiC LGADs. Ongoing work focuses on benchmarking SiC-LGAD gain simulations within AllPix² and comparing the results to TCAD for validation.

Will the talk be given in person or remotely?

In person

Authors: GSPONER, Andreas (Austrian Academy of Sciences (AT)); ONDER, Sebastian (Austrian Academy of Sciences (AT)); GUNDACKER, Stefan (Austrian Academy of Sciences (AT))

Co-authors: BURIN, Jürgen (Austrian Academy of Sciences (AT)); WAID, Simon Emanuel (Austrian Academy of Sciences (AT)); BERGAUER, Thomas (Austrian Academy of Sciences (AT))

Presenter: ONDER, Sebastian (Austrian Academy of Sciences (AT))

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