Contribution ID: **109** Type: **not specified**

Development of Ultra-Thin LGADs with Enhanced Timing Capabilities and Radiation Hardness for Future Collider Applications

Wednesday 15 January 2025 12:02 (13 minutes)

\documentclass[12pt]{article}
\usepackage{amsmath}
\usepackage[margin=1in]{geometry}

\begin{document}

\title{Development of Ultra-Thin LGADs with Enhanced Timing Capabilities and Radiation Hardness for Future Collider Applications}
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\maketitle

\begin{abstract}
This study investigates Low Gain Avalanche Detectors (LGADs) for future particle collider experiments, aiming to improve timing resolution ($<$ 20 ps) under very high-radiation environments. Using the WeightField2 simulation program, we optimized an n-in-p type LGAD design, focusing on ultra-thin sensors ($\sim<$ 50 μm) with p-doped Silicon bulk. Our results show that a 20 μm thick sensor achieves optimal performance. \sloppy Simulations were performed under High Luminosity LHC conditions (temperature $\approx -15\ ^{\circ}$C, luminosity $\approx 7 \times 10^{34}\,\mathrm{cm}^{-2}\,\mathrm{s}^{-1}$), taking into account radiation damage, gain quenching, and lattice defects. Further studies were extended to Silicon Carbide (SiC) bulk material due to its superior properties, such as a wide band-gap and high atomic displacement energy, which provide strong resistance to irradiation. Its high electron saturation drift velocity and thermal conductivity make it a fast-responding detector with lower thermal sensitivity. After irradiation, the study investigates fast charge collection, breakdown voltage, leakage current, and radiation tolerance, comparing these with conventional Silicon-based LGADs. For instance, SiC-based LGADs demonstrated lower leakage current and enhanced radiation tolerance. Additionally, simulations were conducted using laser with wavelength falling in near-infrared region, to observe charge collection across the detector strip, identifying the optimal zone for MIP hitting. These findings underline the potential of optimized LGADs in maintaining performance under high radiation regime.

\end{abstract}

\noindent \textbf{Keywords:} LGAD, timing resolution, radiation hardness, ultra-thin sensors, Silicon Carbide, WeightField2 simulation

\end{document}

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Session Classification: Parallel A

Track Classification: 9. Future experimental programs