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TCAD simulation study of Novel AC-LGAD design with isolation Structures for sensor performance optimization

Abstract:
AC-LGAD (AC-Coupled Low-Gain Avalanche Diode) detector shows great potential for future particle physics and vertex detectors due to their excellent timing resolution and spatial resolution. However, their performance is limited by the sensor's internal capacitance parameters, particularly the bulk capacitance and the inter-strip capacitance.
High capacitances of AC-LGAD with centimeter long strips can degrade the signal response speed and increase crosstalk, thereby impairing the timing accuracy and spatial resolution.
To address this challenge, this study proposes a novel structural design for AC-LGAD sensors with isolation structures. Through detailed 2D and 3D numerical simulations, we systematically analyzed the suppression effect of the new structure on key capacitance parameters, including bulk capacitance, coupling capacitance, and inter-strip capacitance. The simulation results demonstrate that the new design significantly reduces the overall capacitance. For sensors with this optimization design, we simulate and analyze the charge distribution characteristics of strips as the injection point changes. Based on these results, we further investigated the electrical performance of the sensor: the signal rise time, collected charge performance and the spatial resolution. These results will be discussed in the report.

Keywords: AC-LGAD, isolation structure, Capacitance Optimization;;TCAD Simulation;Timing and spatial resolution;

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