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Development of AC-LGADs for large-scale high-precision time and position measurements

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Low Gain Avalanche Detectors (LGADs) are thin silicon detectors with moderate internal signal amplification, providing time resolution as good as 17 ps for minimum ionizing particles. In addition, their fast rise time and short full charge collection time (as low as 1 ns) is suitable for high repetition rate measurements in photon science and other fields. However, a major limiting factor for spatial resolution are electric field termination structures, which currently limit the granularity of LGAD sensors to the mm scale.
AC-LGADs, also referred to as resistive silicon detectors, are a recent variety of LGADs based on a sensor design where the multiplication and n+ layers are continuous, and only the metal layer is patterned. This simplifies sensor fabrication and reduces the dead area on the detector, improving the hit efficiency while retaining the excellent fast timing capabilities of LGAD technology. In AC-LGADs, the signal is capacitively coupled from the continuous, resistive n+ layer over a dielectric to the metal electrodes. A high spatial precision on the few 10‘s of micrometer scale is achieved by using the information from multiple pads, exploiting the intrinsic charge sharing capabilities provided by the common n+ layer. The response depends on the location, the pitch and size of the pads.
Using focused IR-laser scans, the following detector parameters have been investigated with the scope of optimizing the sensor design: sheet resistance and termination resistance of the n-layer, thickness of the isolation dielectric, and pitch and size of the readout pads. Furthermore, capacitance-voltage characterization of the sensors will be shown. Finally, charge sharing distributions produced with data taken at the Fermilab test beam facility will be presented. The results will be used to recommend a base-line sensor for near-future large-scale detector application like the Electron-Ion Collider, where simultaneous precision timing and position resolution is required.

Collaboration

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