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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. LGADs can provide time resolution as good as 17 pico-seconds for minimum ionizing particles. In addition, the fast rise time and short full charge collection time (as low as 1 ns) of LGADs are suitable for high repetition rate measurements in photon science and other fields. However the current major limiting factor in granularity is due to structures preventing breakdown caused by high electric fields in near-by segmented implants. As a result, the granularity of LGAD sensors is currently limited to the mm scale.

In this contribution, we present measurements on AC-LGADs (also named Resistive Silicon Detectors RSD), a version of LGAD which has shown to provide spatial resolution on the few 10's of micrometer scale. This is achieved by un-segmented (p-type) gain layer and (n-type) N-layer, and a di-electric layer separating the metal readout pads. The high spatial precision is achieved by using the information from multiple pads, exploiting the intrinsic charge sharing capabilities of the AC-LGAD provided by the common N-layer. The response depends on the location, the pitch and size of the pads.

Using a focused IR-Laser scans directed both at the readout side on the front and the bias side on the back of the sensor, the following detector parameters have been investigated in RSD produced by FBK with the scope of optimizing the sensor design: sheet resistance and termination resistance of the n-layer, thickness of the isolation di-electric, doping profile of the gain layer, and pitch and size of the readout pads. Furthermore the electrical characterization (capacitance over voltage) of the sensors with different connection configurations will be shown. Finally, charge sharing distributions produced with data taken at the Fermilab test beam facility in the spring of 2021 will be shown. The data will be used to recommend a base-line sensor for near-future large-scale application like the Electron-Ion Collider where simultaneous precision timing and position resolution is required in the tracking detectors.

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