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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 (ranging from 20 to 50 um in thickness) with moderate internal signal amplification (up to a gain of ˜50) [1]. LGADs are capable of providing measurements of minimum-ionizing particles with time resolution as good as 17 pico-seconds [2], [3]. In addition, the fast rise time (as low as 150 ps) 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.
The first implementation of this technology will be with the High-Granularity Timing Detector (HGTD) in ATLAS and the Endcap Timing Layer (ETL) in CMS for the high luminosity upgrade at the Large Hadron Collider (HL-LHC). The addition of precise timing information from LGADs will help mitigate the increase of pile-up and improve the detector performance and physics sensitivity.
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 paper, 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 [4]. 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. It depends on the location, and the pitch and size of the pads.
Using a focused IR-Laser scans directed alternatively at the read-out side on the front and the bias side on the back of the AC-LGAD, the following detector parameters have been investigated in RSD produced by FBK [4]: 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.
The data are 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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