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Updates on charge sharing and radiation hardness of AC-LGADs for near-future Higgs factories and nuclear physics experiments

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Low Gain Avalanche Detectors (LGADs) are characterized by a fast rise time (~500ps) and extremely good time resolution(down to 17ps), and potential for a very high repetition rate with ~1 ns full charge collection. For the application of this technology to near future experiments such as e+e- Higgs factories, the ePIC detector at the Electron-Ion Collider, or smaller experiments (e.g., the PIONEER experiment), the intrinsic low granularity of LGADs and the large power consumption of readout chips for precise timing is problematic. AC-coupled LGADs, where the readout metal is AC-coupled through an insulating oxide layer, could solve both issues at the same time thanks to the 100% fill factor and charge-sharing capabilities. Charge sharing between electrodes allows a hit position resolution well below the pitch/sqrt(12) of standard segmented detectors. At the same time, it relaxes the channel density and power consumption requirement of readout chips. Extensive characterization of AC-LGAD devices with both laser TCT and probe station (IV/CV) will be shown in this contribution, comparing the effect of various parameters among the readout electrode dimensions (strip/pad metal contact length and width, pitch) and sensor production details (manufacturer, N+ layer resistivity, dielectric capacitance, bulk thickness, doping of the gain layer). The data suggests that the length of the strip plays a dominant role in determining the extent of long-distance cross- talk and/or pick-up; on the other hand, the N+ layer resistivity influences the strength of the shared signal. We will also discuss our efforts at replicating the observed behavior of the sensors, including the capacitive and resistive circuitry on the fast readout boards used for sensor testing, in 2D and 3D TCAD simulations.

We will present the first results on AC-LGADs irradiated with 1 MeV reactor neutrons at JSI/Ljubljana to fluences on the order of 1e13 to 1e15 n/cm2. As observed in all silicon sensors, leakage currents and full depletion voltage points increase with irradiation. The radiation hardness of the gain layer, i.e. the electrical deactivation of Boron dopants, is determined by C-V measurements, showing the sensors to be radiation hard to lower fluences as relevant in e.g. the EIC, but degrading the gain at 1e15 n/cm2. Changes in the charge sharing profile across strips are observed in laser TCT measurements, indicating an increase of signal sharing potentially explained by degradation of the surface passivation, however not critically affecting sensor performance.

Finally, using a rotational stage in our laser TCT system we will show our initial investigation of charge sharing in AC-LGADs for hits incident on the sensor at an angle, to evaluate the effect of the tilted installation which is typical for silicon pixel and strip sensor modules in tracking detectors.

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