Contribution ID: **143** Type: **poster**

High-performance HV-CMOS sensors for future particle physics experiments - An overview

Wednesday 15 September 2021 15:56 (1 minute)

Traditional hybrid silicon sensors are the most common tracking sensor technology in current particle physics experiments with high rates. However the limitations imposed by their composite structure make them unsuitable for many future experiments that require low material budget and high spatial resolution. High Voltage-CMOS (HV-CMOS) sensors, due to their significant advantages, are emerging as a prime candidate for future tracking applications that have extreme requirements on the material budget, granularity, time resolution and radiation tolerance.

HV-CMOS sensors integrate both the silicon sensor and readout ASIC into the same silicon substrate, thus eliminating the need for complex and laborious bump-bonding. The high voltage, at which the substrate is biased, creates a wide depletion region for fast charge collection by drift and high radiation tolerance. The feasibility of integrating analog and digital readout electronics on the same chip allows the production of fully monolithic HV-CMOS sensors. Therefore, HV-CMOS sensors have become a promising solution for future particle physics experiments, such as the Mu3e experiment, future upgrades of the Large Hadron Collider (LHC) and the Circular Electron Positron Collider (CEPC).

Despite the major improvements already demonstrated by HV-CMOS sensors, the enormous challenges set by future experiments demand substantial research to achieve further enhancements. The main goal of our R&D programme at Liverpool is to push the boundaries of HV-CMOS sensors to achieve a step-change improvement in their performance, especially in terms of single point resolution, fast-timing capability and radiation tolerance. This talk will give an overview of the latest developments in HV-CMOS sensors done by our group and present the design and measured results of a new HV-CMOS prototype chip. This chip is designed to further improve the radiation tolerance and time resolution of HV-CMOS sensors.

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Session Classification: Poster Session 3 (Applications in Particle Physics)

Track Classification: Applications in Particle Physics