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Novel strategies for high-granularity and radiation hardness LGAD sensors

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Low-gain avalanche diodes (LGADs) are being considered as a viable solution for 4D-tracking due to their excellent time resolution and good resistance to high radiation fluence. However, conventional LGAD sensors have a limited pixel dimension of 0.5-1 mm due to the presence of a non-sensitive region between pixels. This region, typically 60-70 µm wide, is the main factor restricting the decrease in pixel size for LGADs. As part of the RD50 collaboration, Trench-Isolated LGAD (TI-LGAD) sensors have been developed and fully characterized at KIT. These sensors have small pixels as small as 50 µm and a 100% fill factor.
This contribution will discuss the layout design rules, parameters, and their impact on the performance of spatial, time, gain, and noise. In addition, based on the accumulated results and experiences, an engineering run design has been developed at KIT and is currently undergoing production. The design contains pixelated and microstrip sensors, with a channel pitch as small as 25 µm, and is expected to achieve a time resolution below 20 ps. The production batch is split into several processes to ensure the production of devices suitable for particle physics, modern photon sciences, and space applications. At present, FBK is in the process of manufacturing these sensors, and the delivery is scheduled to be in November 2024.
Moreover, KIT is collaborating with the Santa Cruz Institute for Particle Physics to design a novel structure based on segmented thin LGADs known as Deep-Junction LGADs, which ensure very high gain uniformity combined with the excellent time and spatial performance. By adjusting the design and controlling the p/n degradation caused by radiation damage, this type of LGAD has the potential to significantly increase the radiation-hardness of LGADs.

The primary goal of this development and its subsequent production is to enhance silicon sensors, resulting in improved time, energy, and position resolution within the Helmholtz system. The successful implementation aims to establish the availability of sensors with high spatial (20 µm) and time resolution (20 ps) for charged particles, therefore contributing to milestone MT DTS-2.

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