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Investigating the Impact of Isolation Structure Configurations on the Charge Carrier Excess in the Inter-Pad Region within Low and High-Injection Carrier Dynamics: Comparative study of LGADs with 2 p-stops and Bias ring in IP Region vs. Configuration with Two Trenches

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We present an in-depth investigation of the inter-pad (IP) gap region in the Ultra Fast Silicon Detector (UFSD) Type 10, utilizing a femtosecond laser beam and the transient current technique (TCT) as probing instruments. The sensor, fabricated in the TI-LGAD RD50 production batch at FBK Foundry, enables a direct comparison between TI-LGAD and standard UFSD structures. This research aims to elucidate the isolation structure in the IP region and measure the IP distance between pads, comparing it to the nominal value provided by the vendor. Our findings also reveal unexpectedly strong signal induced near p-stops. This effect is amplified with increasing laser power, suggesting significant avalanche multiplication, and is also observed at a moderate laser intensity and high HV bias. The high-injection carrier dynamics induce large space-charge effects that disturb the local electric field, thereby affecting the peak, shape and the duration of a transient waveform. Furthermore, the study on LGADs with 2 p-stops and bias ring in IP region was extended to the Trenched LGADs with two trenches. Much stronger charge carrier excess, measured in the inter-pad region of 2Tr Ti-LGADs, may be attributed to the proximity of the two trenches and the closer proximity of one trench to the neighboring pixel (its gain layer) that increases significantly the electric field in the IP region. Additionally, the defects due to trench etching may modify the electric field in IP region leading to the significant variation in the charge collection. This investigation contributes valuable insights into the IP region's isolation structure and electric field effects on charge collection, providing critical data for the development of advanced sensor technology for the CMS and ATLAS experiments and other high-precision (with high density charge) applications.

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