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N-type LGADs for Particle and Photon Detection

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Low-Gain Avalanche Diodes (LGADs) are typically fabricated on p-type substrates, following an n–p⁺–p junction configuration, where a boron-doped layer forms the gain region.
This architecture is considered optimal for timing and particle-tracking applications since the primary charge carriers initiating the avalanche process are electrons, which feature higher drift velocity and ionization coefficient compared to holes. However, for the detection of low-penetrating particles, such as soft X-rays, the conventional p-on-n configuration becomes less efficient. In these cases, most carriers are generated close to the front junction (n-type region) or within the high-field gain layer, resulting in reduced gain and possibly lower signal-to-noise ratio (SNR).
To overcome these limitations and improve the detection efficiency of low-energy photons and particles, LGADs on n-type substrates (N-LGADs) have been recently proposed. This inverted doping configuration, compared to standard LGADs, is expected to deliver higher gain and SNR for low-penetrating radiation, particularly for X-rays below 1 keV.
The fabricated N-LGADs employ 55 µm-thick n-type epitaxial substrates, with the front junction formed by boron ion implantation. Several junction depths and doping profiles have been implemented to investigate QE and Gain vs interaction depth as a function of junction design. Electrical characterization (I-V, C-V, and gain measurements) will be presented for the different splits, along with optical characterization in the 380–950 nm wavelength range. The latter enables the determination of Gain and QE as a function of the charge generation depth, providing a comprehensive comparison among the various device configurations.

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