

nLGAD detector gain performance in the deep and near-ultraviolet (UV) spectral range

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Low Gain Avalanche Detectors (LGADs) are silicon detectors produced in a specialized way, such that they possess an internal charge multiplication effect (gain) that amplifies the output signal and allows for a good signal-to-noise ratio. Their stable and controlled moderate gain of up to 50, along with exceptional timing resolution, justifies their role as a baseline for HEP experiments. This enables particle tracking, which is important for collider experiments (CERN-LHC). Originally developed at CNM [1], this technology has since diversified, with various “flavours” emerging, each intended for different detection applications. In this work, we show the potential of the nLGAD, which is particularly aimed at low-penetration radiation (penetration depth around $\lesssim 1 \mu\text{m}$). This is due to the nature of the charge transport dynamics in n-type semiconductor and its correlation with the specially designed doping profile, which enhances sensitivity to low penetration – particularly important in fields like soft X-ray imaging of biological samples in the water window (282 eV to 533 eV). The first simulations and gain response measurements of such devices, characterised with 404 nm (blue), 660 nm (red), 1064 nm (infrared light), 15 keV X-rays, and 600 keV protons can be found in [2–4]. These results show that the nLGAD maintains high gain at shorter wavelengths and lower penetration, confirming the consistency of the low penetration, high gain relationship. The results confirmed the viability of the nLGAD and have motivated the optimisation of this technology at CNM. In this study, we extend the characterization of this technology, presenting the gain measurements in the deep and near-ultraviolet (UV) 250–390 nm wavelength range performed at The Extreme Light Infrastructure (ELI ERIC) facility (Prague, Czech Republic). We focus the discussion on the effects of fabrication refinements such as variations in doping profile for the entrance window optimization. Findings in this work demonstrate that making the dead layer (low electric field region) thinner improves deep UV detection, and that our technology is still able to detect wavelength down to 250 nm with a gain of 2–3. However, this study strongly suggests the need for an ultra-shallow junction in the future, which will be a new benchmark for nLGAD for detecting low-penetration radiation. Our results also show that optimizing the entrance window is crucial, not only due to its thickness but also because of the significant variation in the reflectance coefficient across the deep and near UV range. This implies that antireflective coatings are mandatory for passivating nLGADs, especially for possible applications in VUV optics (10 nm – 200 nm), where challenges with shallow penetration would be even more pronounced.

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