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Low Gain Avalanche Diodes for Photon Science Applications

Low Gain Avalanche Diodes (LGADs) are silicon sensors with an internal gain in the order of 10 obtained via the impact ionization process.
The initial technological implementation of the sensors constrains their minimum channel size to be larger than 1 mm^2 in order to reduce inefficiencies due to the segmentation of the gain structure. In photon science, the gain provided by LGAD sensors can boost the signal-to-noise ratio of the detector system, effectively reducing the x-ray energy threshold of photon counting detectors and the minimum x-ray energy where single photon resolution is achieved in charge integrating detectors. This can improve the hybrid pixel and strip detectors for soft and tender x-rays by only changing the sensor element of the detector system. Photon science applications in the soft and tender energy range require improvements over the LGADs developed for other applications, in particular the presence of a thin entrance window to provide a satisfactory quantum efficiency and channel size with a pitch of less than 100 μm. In this review, the fundamental aspects of the LGAD technology are presented, discussing also the ongoing and future developments that are of interest for photon science applications. In particular, novel structures were recently proposed to improve the sensor segmentation while keeping the regions where no gain structure is present to a minimum: double sided (inverted) LGADs, trench-isolated LGADs, and AC-coupled LGADs are examples of the structures discussed in this talk. The measured and expected properties of available and proposed LGAD structures are discussed for several aspects relevant to photon science applications such as the impact of the placement of the gain structure on quantum efficiency, the sensor's signal characteristics and its compatibility with available readout chips.

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