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Gain, noise, and collection efficiency of GaAs SAM-APDs with staircase structure by means of synchrotron radiation

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In hard-X-ray applications that require high detection efficiency and short response times, III/V compound semiconductors offer some advantages over the Si-based technologies traditionally used in solid-state photodetectors. Amongst them, GaAs is one of the most valuable materials thanks to its outstanding properties. At the same time, implementing charge-multiplication mechanisms within the sensor may become of critical importance in cases where the photogenerated signal needs an intrinsic amplification to be acquired with adequate precision by the front-end electronics. To fulfill these needs, a number of GaAs-based avalanche photodiodes (APDs) were grown by molecular beam epitaxy; through bandgap engineering, it was possible to realise devices with separate absorption and multiplication regions, the latter of which featuring a so-called staircase structure to reduce the multiplication noise. This work reports on the experimental characterisation of gain, noise and charge collection efficiency of three series of GaAs APDs featuring absorption regions of different thicknesses. Several measurements were carried out on such devices both with lasers and synchrotron light sources. The results, supported by simulations based on state-of-the-art modelling, show the capability of these devices to operate in non-punch-through regime with promising performances in terms of collection efficiency, gain and associated noise.

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