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Design and Development of Ultrafast Scintillator with Monolithically Integrated Photodetector for Radiation Detection

Scintillators with excellent timing and light-yield performance are on high demand by high energy physics experiments as well as medical imaging and nuclear security application. Epitaxially grown InAs quantum dots (QDs) embedded in GaAs matrix have been demonstrated to be a viable material for ultrafast radiation detection due to its higher light yield projected to 240 ph./keV, due to narrow GaAs bandgap, high (˜60%) QDs luminescence efficiency at room temperature and low self-absorption, thus surpassing the physical limits of inorganic scintillators.
The fabricated InAs/GaAs QD heterostructures with monolithically integrated p-i-n photodiodes (PD) were analyzed using ²⁴¹Am 5.5 MeV alpha-particle source. Distributions of charge collected by the PD appear bi-modal corresponding to geometry of the PD and the scintillating waveguide. With Monte Carlo (MC) simulations, waveguiding features such as absorption and surface scattering are assessed and its impact on detector performance is investigated. MC analysis was used to evaluate charge collection statistics, optical travel length, and time (optical jitter), which aided in the design of a scintillator pixel and integrated photodetector (PD). The waveguiding integrated scintillation detector demonstrated mean charge collection of 30 el./keV or 13% of the theoretically achievable light yield, a decay time of 300 ps and 38 ps time resolution.

Primary experiment

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