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Characterization of New Avalanche Photodiode Arrays for Positron Emission Tomography

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The aim of this study was the characterization and performance validation of new prototype avalanche photodiode (APD) arrays for positron emission tomography (PET). Two different APD array prototypes (noted A and B) developed by Radiation Monitoring Device (RMD) have been investigated. Principal characteristics of the two APD array were measured and compared. In order to characterize and evaluate the APD performance, capacitance, doping concentration, quantum efficiency, gain and dark current were measured. The doping concentration that shows the impurity distribution within an APD pixel as a function of depth was derived from the relationship between capacitance and bias voltage. Quantum efficiency was measured using a mercury vapor light source and a monochromator used to select a wavelength within the range of 300 to 700 nm. Quantum efficiency measurements were done at 500 V, for which the APD gain is equal to one. For the gain measurements, a pencil beam with 450 nm in wavelength was illuminating the center of each pixel. The APD dark currents were measured as a function of gain and bias. A linear fitting method was used to determine the value of surface and bulk leakage currents. Mean quantum efficiencies measured at 400 and 450 nm were 0.41 and 0.54, for array A, and 0.50 and 0.65 for array B. Mean gain at a bias voltage of 1700 V, was 617.6 for array A and 515.7 for type B. The values based on linear fitting were 0.08 ± 0.02 nA 38.40 ± 6.26 nA, 0.08 ± 0.01 nA 36.87 ± 5.19 nA, and 0.05 ± 0.00 nA, 21.80 ± 1.30 nA in bulk surface leakage current for array A and B respectively. Results of characterization demonstrate the importance of performance measurement validating the capability of APD array as the detector for PET imaging.