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Radiation damage of Silicon Photomultipliers by irradiated fast neutrons

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Silicon Photomultipliers (SiPM) are beginning to be actively used in high-energy physics experiments (CMS, LHCb, ATLAS in CERN), therefore careful study of the effect of high radiation fields on the operation of these devices is necessary. This work studies the effect of irradiation with fast neutrons on the work of SiPM (manufacturing: Hamamatsu Photonics K.K.) with an active area of 1 mm^2 (types -010C, -015C, -1325CS) and 9 mm^2 (-015P) with the equivalent fluence 1 MeV neutrons in range from 10^{11} to $5 \cdot 10^{14}$ cm^{-2}.

Summary

The following main parameters of a SiPM were measured and analyzed before and after irradiation: the dependence of the coefficient of multiplication on the overvoltage, current-voltage (I-V) and capacitance-voltage (C-V) characteristics. It was determined that after irradiation a few negative effects appear: an increase of dark current and breakdown voltage. Dark current in non-irradiated SiPM are formed due to the process of thermogeneration of electron-hole pairs in a silicon volume, and value of dark currents depends on effective lifetime for these charge carriers, which decreases in the process of irradiation due to the creation of radiation defects in epitaxial layer (space charge region), which leads to growth bulk dark current in region without gain and breakdown voltage. To use the SiPMs in high radiation fields conditions requires the selection of the optimal type of SiPM taking into account the magnitude of the gain, the dynamic range of the measured signals, temperature conditions, and also the correction of the operating voltage with increasing radiation damage.

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