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P1.38: Spreading of an active region of semi-insulating GaAs detectors after radiation degradation

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Semi-insulating GaAs detectors represent an alternative to silicon detectors exhibiting a higher detection efficiency of gamma and X-rays due to higher material density and promising radiation hardness. Previous studies have shown their ability to withstand doses of a few MGy when degraded by MeV electrons with a main limiting factor which is the charge collection efficiency decreasing with overall dose [1]. On the other hand, we have observed the apparent improve of the detection efficiency after initial detector degradation by 5 MeV electrons up to doses of 200 kGy [2] when measuring both the gamma and also alpha particle spectra of 241-Am. This phenomenon was explained by assumed expansion of active detector volume. The projected range of used alpha particles was less than 20 μm in 230 μm thick GaAs substrate, irradiated from Schottky contact side. The detectors have the sandwich structure with 135 nm thick circular Ti/Pt/Au Schottky contact 1 mm in diameter on the top and full area Ni/AuGe/Au ohmic contact on the opposite side of substrate. The deepening of active volume of detector with increasing applied bias was proved previously. However, the short penetration depth of measured alpha particles indicates spreading of active detector volume also to the sides, behind the metallization edge. Fig. 1a shows the increase of detection efficiency with growing applied bias, which was more intensive before detector degradation.
In this paper we evaluate the alpha particle spectra of 241-Am measured by the same semi-insulating (SI) GaAs detectors described in [2] but degraded by 5 MeV electrons up to 2 MGy doses. The detection efficiency is evaluated through integrated counts in peak and shows the continuing increasing tendency up to doses of 600 kGy followed by deterioration in the range of doses from 1 to 2 MGy (Fig. 1b). The assumed spreading of the active area to the sides behind the Schottky metallization was experimentally confirmed by scanning the detector surface with a micro-focused X-ray beam. According to our results, the radiation degradation of SI GaAs detectors has influence on their electric field distribution, which might be important in the case of sensor structures for multipixel detectors.

[1] Sagatova et al.: Alpha-spectrometry by radiation-degraded semi-insulating GaAs detectors. In Materials Today: Proceedings, 2022, vol. 53, no. 293.
[2] Sagatova et al.: Radiation hardness study of semi-insulating GaAs detectors against 5 MeV electrons. In Journal of Instrumentation, 2018, vol. 13, no. C01006.

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