Contribution ID: **163** Type: **Oral**

Characterization of SiC Timepix3 Detector and Spectral-Tracking Response to Protons and Mono-Energetic Fast Neutrons

Wednesday, 28 June 2023 11:20 (20 minutes)

The semiconductor pixel detectors of the Timepix family provide position-, time- and directional-sensitive spectrometry for high-resolution wide-range spectral tracking of single particles [1]. These properties are valuable also for inspection and as testing probe of properties and homogeneity of radiation response and charge collection of the semiconductor sensor. The hybrid architecture of the Timepix family of detectors enables the use of different semiconductor sensors most commonly silicon or also high-density materials such as CdTe and GaAs. Newly radiation hard materials are being investigated, such as SiC [2], which offer large displacement energy, large band gap, and can operate at elevated temperatures up to several hundreds of degrees Celsius. As a result, this sensor material is more suitable for radiation harsh environments compared to traditionally available Si sensors. In this work we use two newly developed SiC sensors operated at 200V bias with depleted depth of 65 µm out of 80 µm thick epitaxial layer [2] which are bump-bonded to the Timepix3 ASIC chip. The detector is operated and readout in the compact radiation camera MiniPIX Timepix3 [3]. We performed measurements with proton beams at 13, 20 and 31 MeV at the U-120M cyclotron at NPI CAS Rez near Prague and at 100 and 226 MeV at the Proton Therapy Center Prague. In addition, the response of the SiC Timepix3 detector to fast neutrons was also studied. Measurements were carried out with mono-energetic fast neutrons at selected energies in the range 400 keV to 16 MeV at the Van de Graaff accelerator at the IEAP CTU Prague. The detection of protons and neutrons of selected energies by the SiC Timepix3 MiniPIX detector is shown in Fig. 1. High-resolution pattern recognition analysis and spectral tracking of single particles serve as a probe for inspection and detailed understanding of the SiC sensor signal and charge collection response, homogeneity. The goal is to use the device as a particle tracker for composition and spectral characterization [4] of different radiation fields. Distributions of deposited energy, linear-energy transfer spectra (LET) and selected cluster-track parameters are shown in Fig. 2 for data from selected experiments. Results will be presented including energy resolution, neutron detection efficiency and comparison with other sensors (Si, CdTe, GaAs).

[1] C Granja et al., NIM-A 908 (2018), 60-71
[2] B. Zatko et al., JINST 17 (2022) C12005
[3] C. Granja, et al., JINST 17 (2022) C03019
[4] A. Novak et al., JINST 18 (2023) C01022

Work in Advacam was performed in frame of Contract No. 40001250020/18/NL/GLC/hh from the European Space Agency. Work at STUBA was supported by the Slovak Research and Development Agency grant APVV-18-0273.

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Session Classification: Sensors

Track Classification: Sensor materials, Device Processing and Technologies