Physics Research and Engineering Applications of Pixel Detectors Timepix with Si, SiC, GaAs and CdTe Semiconductor Sensors

Carlos Granja[1, a)], T. Slavicek[2], J. Gajewski[3], J. Kubancak[4], A. Sagatova[1], Z. Kohout[2], R. Sykora[2], A. Rucinsky[3], P. Stasica[3], R. Langer[4], B. Zatko[5], C. Oancea[6], I. Wilhelm[2], and S. Pospisil[2]

[1]*Institute of Nuclear and Physical Engineering, Faculty of Electrical Engineering and Information Technology, Slovak University of Technology, Bratislava, Slovakia*
[2]*Institute of Experimental and Applied Physics, Czech Technical University in Prague, Czech Republic*
[3]*Centrum Cyclotron Bronowice, Institute of Nuclear Physics, Polish Academy of Sciences, Krakow, Poland*
[4]*Institute of Experimental Physics, Slovak Academy of Sciences, Kosice, Slovakia*
[5]*Institute of Electrical Engineering, Slovak Academy of Sciences, Bratislava, Slovakia*
[6]*Advacam, Prague, Czech Republic*

[a)] *Corresponding author: carlos.granja@stuba.sk*

Abstract. The hybrid semiconductor pixel detectors Timepix are increasingly used in many tasks and radiation-related measurements in basic and applied research [1-5]. The state-of-the-art ASIC chip technology, developed by the Medipix Collaboration based at CERN, together with integrated detector readout electronics [6], advanced data processing [7] and experimental in-beam calibrations [8] makes possible the development of novel techniques of high-resolution radiation imaging [2], particle tracking [9-10], mixed-radiation field characterization [11], radiation and quantum imaging dosimetry [12-13] of a wide variety of radiation fields and applications. The Timepix family of detectors [1-2] provides unique engineering features of high spatial granularity (a high-density matrix of 256 × 256 = 65.536 independent pixels of pitch size 55 µm), integrated per-pixel signal electronics, per-pixel spectral/time/counting response, noiseless dark-current free response and room-temperature operation. Moreover, the hybrid architecture of the ASIC chip-sensor assembly gives the ability to use different semiconductor sensors of different materials (Si [14], SiC [15], GaAs [16], CdTe [17]) and varying thickness. The interaction of radiation in the detector sensor material is significantly determined by the particular radiation species (electrons, protons, ions, X rays, gamma rays, neutrons) and their energy (namely stopping power) as well as on the particular composition of the sensor material. The choice of the sensor thus critically determines the radiation-detector interactions and greatly influences the distinct response and detection resolving power to different radiation species. The choice of the sensor becomes significant in particular for X rays, gamma rays and neutrons whose nature of interaction in matter is primarily indirect. For these radiations various key concepts of radiation detection such as detection efficiency, spectral response and event-type discrimination can greatly vary according to the specific sensor type and configuration used. The importance and suitability of the choice of the sensor type used on the Timepix detectors is reviewed and evaluated according to the needs and aims of the research and the particular radiation-detection task. Selected examples of current applications will be given such as cosmic ray [18] and space radiation research [19], neutron spectrometry [5] and particle radiotherapy dosimetry [3,20].

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