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W2 Perspectives and applications of 4H-SiC and single crystal diamond detectors

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Detectors based on wide bandgap semiconductors and with high radiation hardness are very promising for many applications. The commercial availability of high-quality crystalline material is required for the preparation of high-grade radiation detectors. The 4H-SiC and diamonds are good candidates in term of harsh environment operation. Detectors based on SiC and diamond can operate at higher temperatures and have very high radiation hardness.

We have tested and developed detectors based on low doped 4H-SiC epitaxial layers and single crystal diamond substrates. We have prepared single detector as well as pixeled structures. As SiC and diamond are wide bandgap materials, tested structures show very low current (only few pA) at several hundreds of volts. Prepared detectors were tested using low energy X-rays and gamma rays and alpha particles from 241Am, were they showed high resolution spectroscopy below 20 keV for the energy of 5.5 MeV. In case of X-ray resolution spectroscopy, the main limitation was not due to the detectors but with the noise of used electronics. Detector structures were tested also at increased temperatures where 4H-SiC detectors showed a good energy resolution of 42 keV for 5.5 MeV alpha particles at 500 ℃. Furthermore, we tested SiC and diamond detectors for fast neutron detection in the neutron energy range from 300 keV up to 18 MeV. Mainly diamond detectors showed very high resolution and detection efficiency for fast neutrons. Both detector types clearly show two typical ways of interaction between neutrons and detector materials, elastic scattering and nuclear reaction which produce mainly alpha particles and protons. Due to this, for good neutron detectors the high resolution for alpha-particle detection is needed. Finally, in case of 4H-SiC we have prepared pixelated sensor structures for Timepix3 readout chip. Developed prototype of MiniPIX TPX3 radiation camera had 256×256 pixels. The radiation camera was tested with various types of ionizing radiation like X-ray, gamma rays, protons and neutrons. Also X-ray imaging performance we tested which shows high contrast resolution comparable to commercially available silicon radiation cameras.

Primary author: ZATKO, Bohumir (Intitute of Electrical Engineering, Slovak Academy of Sciences)

Co-authors: SAGATOVA, Andrea (Slovak University of Technology in Bratislava); KURUCOVA, Nikola (Institute of Nuclear and Physical Engineering, Faculty of Electrical Engineering and Information Technology, Slovak University of Technology in Bratislava); KOVÁČOVÁ, Eva (Institute of Electrical Engineering, Slovak Academy of Sciences); VARGA, Marian (Intitute of Electrical Engineering, Slovak Academy of Sciences)

Presenter: ZATKO, Bohumir (Intitute of Electrical Engineering, Slovak Academy of Sciences)

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