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SiC Nuclear Radiation Detectors after Irradiation by Heavy Ions and Neutrons

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Silicon carbide (SiC) is very perspective material for fabrication radiation-tolerant electronics, high-temperature electronics as well as for nuclear radiation detectors for working in harsh environments. SiC has obtained increasing interest due to achievement of a high purity level in the crystal structure and considerable thickness (> 100 μm) in the epitaxial layer. SiC is mostly investigated for its physical properties, e.g.: the band gap energy of the polytype 4H-SiC is 3.26 eV, the mean energy of electron-hole pair creation is 7.78 eV, the electron saturation drift velocity is 2 x 10^7 cm/s and the breakdown voltage is 2 x 10^6 V/cm at room temperature. Detectors based on high quality epitaxial layer of 4H-SiC show a high radiation hardness, good spectroscopic resolution and can operated not only at room but also at elevated temperatures (~300℃) [1,2].
Our detector structures [3] were prepared on a 25 μm or 50 μm thick nitrogen-doped 4HSiC layer (donor doping < l x 10^14 cm-3) grown by the liquid phase epitaxy on a 4" SiC wafer (donor doping ~ 2 x 10^18 cm-3, thickness 350 μm). Circular Schottky Ni/Au contact (diameter 3.0 mm, thicknesses 10/30 nm) to 4H-SiC layer was formed through a contact metal mask, while full area Ti/Pt/Au contact (thicknesses 10/30/90 nm) was evaporated on the other side (substrate).
Electrical characteristic of prepared SiC detectors were measured using Keithley measuring complex, which consisted of 4200A-SCS Parameter Analyzer, 2657A High Power System and CVIV Multi-Switch. Current-voltage and capacity-voltage (C-V) measurements were performed up to 300 V. The reverse breakdown voltage exceeded 300 V and the reverse current was below 10 pA. From C-V measurements the depletion thickness and doping concentration profile were calculated. Spectroscopic parameters were measured with alpha sources 226Ra and 238Pu and FWHM of SiC detectors varied round of 20 keV for 5.5 MeV α-particles energy.
SiC detectors were irradiated by high-energetic beam of heavy ions of Xenon with energy of 165 MeV at the IC-100 cyclotron of the Joint Institute for Nuclear Research (JINR) in Dubna up to dose 1.5 x 10^10 cm-2. We also studied the effect of the degradation of these detectors under impact of neutrons at the neutron reactor IBR-2 (JINR) up to dose 3.4 x 10^15 cm-2.
Prepared SiC detectors shown good energy resolution and high radiation resistance against heavy ions and neutrons and will be used in experiments at JINR.

1. F.H. Ruddy and J.G. Seidel, NIM in Phys. Res. B 263, 163 (2007).
2. D. Puglisi and G. Bertuccio, Micromachines 10, 835 (2019).
3. B. Zat'ko et al., Applied Surface Science 536, 147801 (2020).

The speaker is a student or young scientist

No

Section

1. Applications of nuclear methods in science and technology

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