Contribution ID: **149** Type: **Poster**

A study of particle detectors based on single crystal diamond substrates

Wednesday 3 July 2024 14:27 (1 minute)

Diamond is a very attractive semiconductor material for detectors of ionizing radiation. High carrier mobilities of electrons (2200 cm2/Vs) and holes (1800 cm2/Vs) and excellent radiation hardness are important parameters for radiation detectors. High breakdown voltage and saturation speed are also important in the manufacture of timing detectors. Diamond has a band gap energy of about 5.5 eV and can operate at elevated temperatures. Diamond detectors are good candidates for neutron detection. Carbon is a light atom and has a relatively large cross-section for fast-neutron detection. Another advantage of the diamond detector is its low detection efficiency for X-rays and gamma rays, which is a typical side effect of various types of neutron sources. The main reaction used in fast neutron detection is 12C(n,α)9Be where alpha particles and Be ion are produced, taking away neutron energy. For this reason, it is important to have a diamond detector with high energy resolution for alpha particles.

In our laboratory we prepared diamond detectors based on single crystal diamond substrates with dimensions of 4.1×4.1×0.5 mm3 and 2.1×2.1×0.5 mm3. The thin Pt contact was prepared on one side and the Au contact on the other side. We first measured the current-voltage characteristics of the prepared diamond samples. Measurements were made at room temperature up to 1000 V. The current was in the range of tens of pA at all voltages. Subsequently, diamond detectors were placed in vacuum with a triple alpha particle source 239-Pu238-Pu244-Cm, which produces alpha particles with energies from 5.1 MeV up to 5.8 MeV. Diamond detectors were connected to a spectrometric chain based on a Cremat charge sensitive preamplifier and a Caen Hexagon digital pulse shape amplifier. From the measured alpha particle peaks, we calibrated the detectors and calculated the obtained energy resolution, which was about 0.5 % for detected alpha particles. Prepared diamond detectors showed high energy resolution spectroscopy, which is very important for future use as a neutron spectrometer.

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Session Classification: Poster Session