Diamond Detectors and Their Perspective for Pixelated Neutron Sensors

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Abstract. Diamond is a highly appealing material because of its excellent chemical and physical characteristics, making it ideal for various uses like heavy particle detection, neutron detection, and radiotherapy dosimeters. Its atomic and mass numbers, 6 and 12, are nearly tissue-equivalent, which is a significant benefit compared to materials like silicon. While single-crystal diamonds are very expensive, polycrystalline chemical vapor-deposited (pCVD) diamond films provide a more affordable option. Experimental results show that pCVD diamonds behave similarly to single-crystal diamonds. In this study, we fabricated and tested charged particle detectors based on pCVD diamond films operated at zero bias. The pCVD diamond films were grown on a conductive silicon (100) substrate. Polycrystalline diamond films, with thicknesses ranging from 0.5 μm to 10 μm, were produced via microwave plasma-enhanced CVD. The samples, each roughly 1 cm² in area, featured a full-area Ti/Au (5/50 nm) contact evaporated onto the back side (Si substrate) using ultra-high vacuum deposition. Circular contacts, with diameters between 1 mm and 3 mm, were also created on the diamond layer using the same metallization process. The prepared samples were used to detect alpha particles with an energy of 5.5 MeV emitted by ^{241}Am. The obtained energy resolution was about 15%. The samples were also irradiated with 3.5 MeV protons to fluences up to 10^{16} p/cm^2 to study the degradation of the detection properties. In the final step, we prepared pixelated structures on a 100 μm thick polycrystalline diamond. This structure will be bump-bonded to the Timepix family readout chip to fabricate a radiation camera for fast-neutron detection.

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