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#4-208 Evaluation of 4H-SiC based sensor performances for thermal neutron flux measurements in nuclear power reactor fission facilities

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Silicon Carbide (SiC) based neutron sensors present very promising properties for neutron flux measurements: selectivity between neutron and gamma radiations, response linearity, radiation and temperature hardness, pixilation…In particular, p-n and SCHOTTKY diode designs are studied since more than 20 years for almost fission, fusion, medical, spatial and high-energy physics application cases.
In 2021, CEA, AMU (Aix-Marseille University), within the framework of their joint laboratory LIMMEX, and FRAMATOME started a study to explore 4H-SiC diodes as possible ex-core thermal neutron detectors by using 10B converter for nuclear power plants. Following a first exploratory measurement campaign of Boron implanted 4H-SiC p-n diode sensors performed in 2021 in the Slovenian TRIGA reactor facility (Jožef Stefan Institute), new diodes have been manufactured with the aim of improving their thermal neutron sensitivity: larger surface (around 1 cm^2) and a 1 µm thick layer of B4C coating.
These diodes have been irradiated in the same reactor in March 2023. A degradation of diode responses was observed as neutron fluence becomes significant. Investigations of the possible phenomena at the origin of the observed degradation of detector performances raise suspicions of defects induced linked to 10B(n, ⊠)7Li reaction product impacts which deposit their whole energy in the diode depleted area. A literature review confirmed this hypothesis. A model, based exclusively on carbon vacancies concentration, was proposed to simulate degradation of detector performances. It gives a good estimate of the typical fluence of reaction products that leads to a loss of counting rate (around 109 particles.cm-2).
In addition, a simulation analysis using SRIM software showed that detector sensitivity might be slightly improved by increasing B4C layer thickness up to 3.5 µm and also by using other converter materials, like 10B4C (100 % enriched in 10B) or 6LiF (100 % enriched in 6Li). However, it doesn't appear to be possible to extend the detector service life to a high neutron fluence without reducing its efficiency.
This study concludes with an analysis of the performances and limitations of this kind of sensor as sensor for thermal neutron flux measurement in reactor facilities.

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