Direct Deposit and Placement of Am-241 Alpha Source on SiC Sensors for Their Performance Evaluation

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Abstract:

The large band-gap (3.27 eV) of silicon carbide (SiC) offers a low leakage current and large displacement energy that warrants SiC as one of the candidates for high flux neutron detection in advanced reactors and for safeguard-relevant actinide monitoring in the nuclear fuel cycle.

The damage produced by alpha particles is strongly localized close to the ion's projected range with the typical defect levels at EC-0.72 eV, which exhibits acceptor-type characteristics. Studies of charged particle radiation damage on SiC have mainly relied on using an accelerator to produce high fluences such as 10^10 cm^−2. This work introduced two simpler methods to induce radiation damage by a high fluence of alpha particles on SiC Schottky diodes. Firstly, a total of sixteen 4H-SiC Schottky diodes, each of 6 mm×7 mm device/active area and 21 μm epitaxial layer, were fabricated by depositing either Ni/Pt or Au on its epi-layer to form a Schottky contact and Ni/Pt on the substrate to form the Ohmic contact. After fabrication, the detector array was packaged into an aluminum enclosure and intimately covered by a thin Am-241 source of 1 mCi. After 4 months of continuous alpha irradiation, all 16 devices have received alpha fluence on the order of 10^14 cm^-2. The post-irradiation characterization has shown that 7 out of 16 devices have minimal performance degradation. It was also found that the Ni/Pt SiC Schottky devices were more radiation-resistant than Au/SiC Schottky devices, manifesting the nickel silicide formation.

Secondly, the in-house fabricated 4H-SiC Schottky diodes were electroplated with Am-241 source on their metal contacts, which formed a continuum irradiation condition in the life span of the devices. The type of SiC sensors has been monitored periodically to evaluate their performance, offering a degradation evaluation method that could last for years.