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Electron, neutron and proton irradiation effects on four-quadrant SiC radiation detectors

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Owing to their low dark current, high transparency, high thermal conductivity and potential radiation hardness, there is a special interest in silicon carbide devices for radiation monitoring in radiation harsh environments or operation at elevated temperatures.

In this work, segmented four-quadrant pn junction diodes produced on epitaxied 4H-SiC substrates are studied. The impact of 2-MeV electron, neutron and 24-GeV/c proton irradiations (up to fluences of $1\text{x}10^{16}e/cm^2$, $3\text{x}10^{17}n/cm^2$ and $2.5\text{x}10^{15}p/cm^2$, respectively) on the electrical characteristics is studied by means of current-voltage (I-V) and capacitance-voltage (C-V) techniques. Relevantly, similar low reverse currents for irradiated SiC devices are obtained regardless of particle type and applied fluences, which are at least about four orders of magnitude lower than comparable Si devices. Electrical rectification character of the diodes is lost for the highest fluences. The effects of irradiation on interquadrant resistance and charge build-up in the interquadrant isolation are also assessed. Additionally, device performance as a detector is investigated under irradiation with a collimated ^{239}Pu-^{241}Am-^{244}Cm tri-alpha source. As a validation for sensing applications, SiC device performance as a radiation detector is preserved at room temperature, at least up to $2\text{x}10^{15}n/cm^2$ as well as all other reached electron and proton fluences.

Summarizing, advantages of using SiC devices in alpha particle detection in harsh environments can be envisaged. This study contributes to the milestones in fabrication and radiation hardness assessment of new radiation detectors based on wide bandgap materials, and it is in alignment with the new materials research line objectives in the current RD50 5-years work program.

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