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Enhancing charge collection efficiency in radiation-damaged unmetallized 4H-SiC detectors via LED Illumination

A new generation of 4H-SiC detectors has demonstrated the capability to operate at temperatures up to 450℃, offering excellent spectroscopic response and energy resolution (⊠2%) [1]. This advancement paves the way for the development of silicon carbide detectors designed to measure suprathermal ions (He++ at 3.5 MeV) in extreme radiation and temperature environments, such as those expected in future nuclear fusion reactors like ITER. One of the key challenges to address is the radiation-induced damage. Radiation creates localized defects (trapping centers) in the lattice structure, which capture free charge carriers and lead to charge collection efficiency (CCE) degradation. In this study, we investigate the effect of optical excitation using visible light illumination on the detrapping process of radiation-induced trapped carriers in a 4H-SiC p-n junction unmetallized detector developed by the Institute of Microelectronics of Barcelona (IMB-CNM). The recovery of CCE performance in damaged regions under standard light illumination has been observed in other materials, such as diamond [2]. The detector analyzed in this work was previously irradiated with He beams at 3.5 MeV, creating different damaged regions with cumulative fluences ranging from 1×10^{11} to 1×10^{13} ions/cm² at three different temperatures (from room temperature up to 400ºC) [3]. The spectroscopic response was analyzed at the ion beam nuclear microprobe of the National Accelerator Center (Seville, Spain) using the Ion Beam Induced Charge (IBIC) technique under Light Emission Diodes (LEDs) illumination at different wavelengths to study the influence of light-assisted detrapping on CCE recovery. Our results reveal that illumination induces a significant detrapping process, with higher efficiency in regions of increased trap density. Furthermore, the detrapping effect is intensity-dependent, suggesting a controllable mechanism for performance enhancement. These findings propose a simple yet effective approach to mitigate radiation damage effects, offering a potential strategy to optimize the functionality of SiC-based detectors in harsh fusion environments.

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