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Isotopic Enriched and Natural SiC Junction Barrier Schottky Diodes Under Heavy Ion Irradiation

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***Abstract*—The radiation tolerance of isotopic enriched and natural silicon carbide junction barrier Schottky diodes are compared under heavy ion irradiation. Both types of devices experience leakage current degradation as well as single-event burnout events. The results were comparable, although the data may indicate a marginally lower thresholds for the isotopic enriched devices at lower linear energy transfer (LET). Slightly higher reverse bias threshold values for leakage current degradation were also observed compared to previously published work.**

***Index Terms*—Heavy ion irradiation, leakage current degradation, monoisotopic, Schottky diodes, silicon carbide, single-event burnout (SEB), single-event effects.**

I. INTRODUCTION

SILICON carbide (SiC) is a wide bandgap semiconductor with favorable material properties for use in power electronics applications. In comparison to silicon, the higher breakdown electric field and thermal conductivity allow SiC devices to operate with higher blocking voltages and at higher temperatures [1], [2]. For SiC power devices, such as high-voltage Schottky diodes and metal oxide semiconductor field-effect transistors (MOSFETs), the build-up of heat can nevertheless lead to reduced material integrity and decreased device performance. The ability to transport heat is therefore an important factor to consider for further development of SiC devices. Studies have shown that isotopic enriched silicon may be one possible way to improve thermal conductivity [3]–[5]. Similar results have also been demonstrated for SiC [6].

Silicon carbide is also an attractive material for power devices used in harsh environments such as space applications. However, SiC power devices are sensitive to particle radiation [7]–[9]. For devices biased in the off state, heavy ion irradiation may result in catastrophic failure such as single-event burnout (SEB), or at voltages below the SEB threshold, leakage current degradation due to multiple single ion strikes. It is suggested that the degradation is caused by local heating effects leading to permanent physical modification of the SiC lattice [8], [10], [11].

Even though it has been shown that isotopic enriched SiC has better thermal conductivity than natural SiC, the consequence of this material property in the performance of electronic devices may be more complex to assess and interpret. Therefore, it is imperative to make electronic components also with pure isotopes and to test them in comparison with the standard devices. This work explores the radiation tolerance between SiC junction barrier Schottky (JBS) diodes manufactured with either natural SiC or isotopic pure SiC, i.e., ^{28}Si^{12}C, when irradiated with heavy ions at linear energy transfer (LET)-values in SiC of 7.7, 14.5, 25.3, and 49.0 MeV-cm^2/mg. Leakage current degradation and SEB events were observed for both types of devices. The onset of degradation occurred at similar bias voltages for the two higher LET values. At the two lower LET-values, degradation was observed at marginally lower bias voltages for the isotopic enriched devices.

II. EXPERIMENTAL METHODS

A. Devices

The devices used for this study were 1.7 kV SiC JBS diodes provided by the Swedish company Ascatron AB (now II-VI Kista AB) – manufactured with either isotopic enriched SiC (^{28}Si^{12}C) or natural SiC. Both types use a 355 μm thick substrate of natural SiC manufactured by the Swedish company Norstel (now STMicroelectronics Silicon Carbide AB). On top of these substrates, the University of Linköping (LiU) has grown 100 μm thick epitaxial layers. The configuration of

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